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Castings versus Weldings

Now that this question is no longer *sub judice*, it is possible to evaluate the immediate potentialities of the two processes. It is perfectly obvious that the case for castings in the recent Mock Trial was based on the latest developments, whereas the opposition quite rightly pointed out that not every foundry produced high-duty castings under metallurgically-controlled conditions. The main argument for weldings appeared to us to be the possibilities of weight reduction without loss of strength, and ability to give rapid delivery for a one-off job. To our mind, much of the research work undertaken by the welding industry is pure waste of time and energy. For instance, repeated determination of the actual tensile strength of weld metal is of minor importance when compared with the question of the ability of the welder to reproduce consistent results. It would be wise to test assemblies carrying "as cast" welds, "peened" welds, and ground and polished welds. Then they should be tried out under conditions of vibration, and the usual run of corrosion tests undertaken. Reference to this type of research would have helped the audience to get a better perspective of welding. Weldings were put forward as a finished entity, whilst the case for castings indicated that the final optimum properties had still to be discovered, but that rapid progress based on scientific and industrial research had been achieved and would be continued.

To do justice to both sides, we believe it would be fair if the allegations as to the low quality of the quoted American weldings were discounted on the one side and the lower costs of weldings on the other side. It is perfectly obvious that, under certain conditions, either the one or the other shows an advantage on a "prime cost" basis. Points of major importance elucidated during the Mock Trial included the case of welding of high-duty iron and the stresses locked up in castings. This made us think that too little attention has been given to this problem by the metallurgists or perhaps the physicists. It is not only castings which contain locked-up stresses, but wrought material also, if it be of a hard and brittle nature. It is not unusual when "ending" cogged bars of high-speed steel—both ends of which are notched about two to four inches away from each end—to see both ends fly off, resulting from a blow at one end. Mr. Templeton very aptly referred to the case of rails breaking after notching with an oxygen cutter. By cutting halfway through, and allowing to stand overnight, it requires but a medium sharp blow to effect fracture. By correlation, a distinguished physicist such as Professor Bragg could immediately explain the fundamental conditions for the creation of locked-up stresses, which knowledge would be equally helpful alike both to founder and welder.

Whilst the verdict of the Jury was obviously facetious, we do believe that the evening was thoroughly worth while, and we congratulate Mr. C. C. Booth, Mr. Barrington Hooper and Dr. Everest for their courage in pursuing the idea against much opposition, including our own. The selection of Mr. R. B. Templeton to present the case for castings was a particularly happy one.

Back Numbers

During the last six years or so in one of the Dominions no fewer than 170 foundries went out of business and 150 new ones were formed. This statement causes one to think of all the vast changes which have been made since THE FOUNDRY TRADE JOURNAL was launched 37 years ago. At that time there was no Institute of British Foundrymen, no Cast Iron Research Association, but excellent reliable castings were made, individual research work was undertaken, and progress was being continuously registered. With the technical organisation of the industry came a plethora of information for which there had been previously but scant opportunity for publication. The output since that time has been so great that, in scientific circles, it is readily admitted that much of it still remains to be assimilated and industrialised. It is because of this that one of America's leading foundry research organisations wishes to complete their files of FOUNDRY TRADE JOURNALS. Yet, because of the rapid technical advances therein registered, back numbers are difficult to come by. It is for this reason that the Editor would be glad to learn of any lengthy series for which our readers, through impending retirement, or similar cause, have no further use. By making those issues available they will be furthering the research activities of the industry they have served.

Book Review

Atlas Metallographicus. Vol. II. Parts 5 and 6. Compiled by Hanemann & Schrader and published by Gebruder Borntraeger Verlagsbuchhandlung, 17, Koester Ufer Berlin, W.35. Price R.M. 18.25.

Atlas Metallographicus is essentially a collection of micrographs and macrographs. Vol. 1 of the Atlas dealt with the metallography of steels, and Vol. 2 with the metallography of cast iron. The two numbers received here are a further addition to Vol. 2.

These new additions illustrate the types of structure to be expected in various commercial castings. The text at the beginning of Part 5 deals with the correlation of the mechanical properties with the structure of grey cast iron. The mechanical properties dealt with in this section include tensile strength, elastic modulus, hardness, notch sensitivity and wear resistance. To complete this introductory material there is a section on the effect of wall-thickness on the structure, tensile strength and hardness, and the variation of the depth of chill in wedge shaped test-pieces for grey irons of various compositions. Much of this material is not new, but it serves, in this context, the useful purpose of linking up the results of research work with observations on actual production castings.

Among the types of castings illustrated micrographically are castings for enamelling, brake blocks and drums, pot and single cast piston rings, centrifugal castings made in cold, warm and hot moulds, and not content with such diversity the authors have endeavoured to show the effect of section size. For instance, typical piston ring structures are given for various overall diameters and different cross sections. Micrographs Nos. 316 to 318 illustrate the effect of lining a steel brake drum with cast iron by centrifuging molten cast iron in the actual steel drum and so welding the lining to the drum. The weld shown is not perfect, there being a sharp "crack" in the zone between the decarburised steel.

Two other points, interesting from a theoretical point of view, are records of the presence of spherulitic or pseudo-temper carbon forms in a hyper-eutectic grey iron (micrographs 269 and 270, Part 5), and the presence of a border of cementite around graphite flakes in a sample taken from an old turbine casting (micrographs 242 to 245, Part 6).

The actual micrographs in the whole of this collection are reproduced on loose sheets held in folders on which the pertinent information is arranged, chemical analyses, critical metallographic descriptions, and wherever possible the tensile strength and hardness. One very attractive feature of the information describing the micrographs is that the "degree of saturation" of each iron is given, that is the value of the ratio $\frac{\text{per cent. C.}}{4.23 - \frac{\text{Si per cent.}}{3.2}}$ This value enables one to tell at a glance whether the iron is hypo-eutectic or hyper-eutectic, and also serves a useful purpose for the correlation of mechanical properties with chemical analyses for irons of varying total carbon and silicon contents.

On the purely metallographic side the work is perfect—the micrographs all show flat fields, no scratches are visible and elementary optical defects are absent. Quite recently an eminent foreign metallurgist said that even to the uninitiated it was obvious that it would be impossible to preserve the graphite in cast iron micro-specimens. Actually, this can now be done, and Atlas Metallographicus is one visible proof of the error of this remark, since, at any rate at high magnifications, the graphite lamellæ are shown perfectly preserved and polished. The authors have not been sparing in illustration, most samples being shown at various magnifications which range from 50 up to 1,500, and accompanying these in many cases are macrographs giving the phosphide network and sulphur distribution.

Hanemann and Schrader have successfully avoided the all too common defect of taking micrographs at unnecessarily high and useless magnifications. The ideal in this direction is the minimum magnification with the greatest resolution, the combination being consistent with a flat field and a sucessful view of the structural elements under consideration.

Finally it can be said that besides being an excellent contribution to the cataloguing and recording of the diverse structures found in cast irons, the whole collection forms an ideal for metallographic attainment. This work, without doubt, is the finest collection of micrographic data on ferrous metallography yet published, and the two new additions further emphasise this view.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Pattern-Plate Materials

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I have been greatly interested in the correspondence between Mr. C. W. Coleman and Mr. Gale, and cannot agree with the former when he states that wood is the most popular material for pattern-plates. Brass patterns properly mounted on correctly-made cast-iron plates are the ideal, though this depends on the article to be cast.

As one who has spent the greater part of his life in some of the most up-to-date foundries in the country, and who has personally made and mounted hundreds of patterns, I can say that practically all were put on cast-iron plates. Occasionally, for a cheap, quick job, we would use wood for the plate. During the past twenty odd years, I have visited hundreds of foundries, and cannot remember ever having seen a brass plate. The great majority were made of cast iron.—Yours, etc.,

A. LAKIN.

A. Lakin & Son,
Totley Rise,
Sheffield.
February 21, 1939.

B.S.S. for Tensile Testing

The Council of the British Standards Institution some time ago authorised the appointment of a Co-ordinating Committee to review all proposals relating to test-pieces for mechanical testing that were incorporated in draft British Standard Specifications with the object of eliminating unnecessary variations.

One of the first tasks which this Committee undertook was that of revising and amplifying B.S. 18 so as to provide a range of test-pieces which were suitable for the tensile testing of all metals. An analysis of the tensile-test requirements included in all current British Standard Specifications was prepared, and from this was derived the standard forms that have been included in the revision of B.S.18. The Specification has been considerably amplified and is now divided into three parts. Part 1 includes definitions of the more commonly used terms in tensile testing. Part 2 sets out the standard forms of tensile test-pieces: these include flat test-pieces for material from 10 s.w.g. thick upwards, round test-pieces, test-pieces from bars

(Concluded in next column.)

Random Shots

At the British Iron and Steel Federation dinner held last week at Grosvenor House, there were 1,530 guests. Whilst this is a reasonable attendance for a Third-Division football team, it must constitute a record for a single sitting at an hotel. Mr. Spencer Summers, speaking after the dinner, pointed out that at most dinners there were three types of people: hosts, guests, and ghosts. The ghosts were those who were really members of the Society but were at that particular function guests of some one individual. No doubt that night the *chef-de-cuisine* wished that a few of that vast crowd were ghosts in reality, present but not occupying any space; being entertained but not consuming any food.

* * *

Walking down the street the other day, wondering whether to dig a "funk hole" in the garden or to buy a steel shelter, "Marksman" suddenly encountered the ideal solution. Parked by the pavement edge was a snug little two-seater car bearing the comforting registration mark, ARP 42! What more could anyone wish for, unless it were ARP 43?

* * *

Farther down the street, however, awaited a stranger sight. There, in the busy traffic of the main thoroughfare, was a Sister of Mercy, completely enshrouded in black robings, tickling up the carburettor of a smart limousine car. This finished, she gathered her yards of clothing around her, stepped in the car and drove off.

* * *

A quarter of a mile farther on, the road makers had "moved in." It was a school holiday evidently, for quite a crowd of urchins armed with borrowed picks, shovels and old prams were feverishly digging up and carting away the wood blocks from the road, whilst the workmen were having their dinner before a cheery brazier!

* * *

It has been proposed that Swansea should build some all-steel houses in its next housing scheme. This idea is not in any way to be confused with the all-stolen houses one sometimes hears of, entirely built of nocturnal liftings from unattended building estates.

* * *

Asked to give some examples of vertebrates by his teacher, a young scholar quickly reeled off his list: "Monkey, donkey, ass, fool."

"Good," replied the teacher. "It's the next vertebrate's turn now."

* * *

Notice seen at the British Industries Fair (perhaps):—"Found, a five-pound note. Will owner please form a queue outside the manager's office."

MARKSMAN.

(Concluded from previous column.)

of various shapes, with separate forms of test-pieces for use in the case of tubes and cast-iron products. Part 3 contains the methods of tests.

The revised specification will be useful to all engineers and others who are responsible for drafting specifications, as well as to technical and educational authorities interested in tensile testing. Copies of this Specification (price 2s. 2d. post free) can be obtained from the British Standards Institution, Publications Department, 28, Victoria Street, London, S.W.1.

Investigation of Some Relationships Between Variables of the Cupola*

By M. M. BARIGOZZI, D.Sc.Tech.

As the result of an inquiry made by the ANIMA† in 1936, data were obtained regarding the construction and operation of nearly 100 cupolas in service in Italy. For each installation, the internal diameter D (corresponding area A), together with the following values, were ascertained by means of a *questionnaire*: C, the charge of coke in kilograms; S, the height of the bed of coke formed by the charge, assuming a specific gravity for the coke of 450 kg. per cub. m. under these conditions; P, the charge of pig-iron corresponding to the charge of coke; K, the proportion of coke to pig-iron expressed as a percentage; G, the quantity of molten cast iron delivered by the furnace per hour; W, the quantity of blast per second; p, the static pressure of the blast in the windbelt; h, the height of the bed of coke, ignoring the first charge C. Other data were collected in this way, but they have no connection with the present investigation.

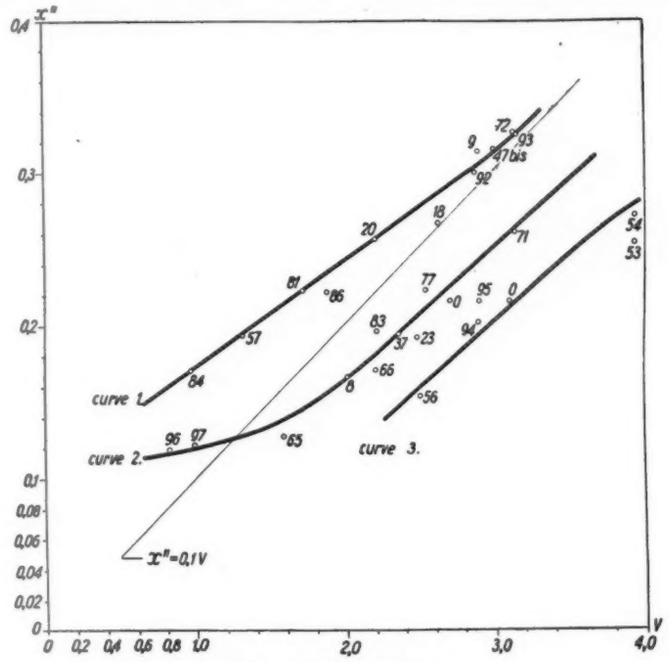


FIG. 1.—X″V DIAGRAM.

According to the relationships which have appeared in various forms in the technical literature,[1] the consumption of coke per second has been calculated as follows:—

$$C'' = \frac{G.K}{360{,}000}.$$

The determination of the phenomena of combustion necessitates a relationship between the blast W and the consumption C″ under the influence of other factors, and it is this which it is desired to ascertain.

As everything occurs vertically in the combustion, it is expedient to refer not to the blast and C″, but to the relationships of these values with A, that is to say, to the blast and consumption reduced to unit surface, *i.e.*,

$$X'' = \frac{C''}{A} \text{ and } V = \frac{W}{A}.$$

It must be admitted that the data collected have only an approximate value and are very remote from scientific accuracy. Although, however, the diameter D is correct only to a few centimetres, and although it varies during operation and there are always errors in the determination of the weights, although the volumes of blast are supplied by different apparatus and no correction has been applied to allow for the temperature and humidity of the air, it must be admitted that, even if a certain statistical regularity can be discerned in the results, despite these imperfections in the data, it would be bold to attempt to deduce definite laws therefrom, but it will still be justifiable to propose to establish a law to be verified by subsequent observations in sufficient number and of suitable accuracy.

Out of nearly 100 furnaces considered, the blast was measured only in the case of 25 of them. Table I shows the values of C″, W, X″ and V. It will be seen at once that the characteristic feature of one class of run is that the value of the blast V is less than 10 times the weight X″ of coke burnt in unit time. In a second class, on the contrary, the values of V are equal to, or greater than, ten times that of X″. In an X″ V diagram (Fig. 1), the straight line V = 10 X″ (or X″ = 0.1 V), starting from the origin, has on its left-hand side a curve, which is designated curve "1" and which is the locus of the characteristic points of runs with a blast less than 10 X″. Towards the upper end, this curve becomes substantially asymptotic to the straight line X″ = 0.1 V. Another curve, the curve "2" is situated completely on the right. This curve is the locus of the points for a blast greater than 10 X″. The straight line X″ = 0.1 V may be regarded as the locus of points corresponding to runs, the index of which is 7:3. (For 1 kilogram of carbon of the coke, the index i is the portion which burns to CO_2, and we shall therefore have indices 1; 0.9; 0.8, etc., up to 0, complete combustion to CO.)

V = 10 X″ is the blast recommended by some authors[2,3] for a run which, with a suitable charge of pig-iron, may be verified with K = 8 on the fundamental assumption made for the whole of this investigation that the coke is always metallurgical coke of average quality and size, with a carbon content of 84 per cent. The theoretical blast necessary for each combustion index for this coke is:

For $i = 0$ (complete combustion to CO)
$V'_t = 4.08\ X''$

For $i = 1$ (complete combustion to CO_2)
$V''_t = 8.16\ X''$ and,

in general, for any index i

$$V_t = 4.08\ (1 + i)\ X''$$

or, in the usual form,

$$X'' = \frac{1}{4.08\ (1 + i)}\ V_t.$$

There is, therefore, a number of straight lines starting from the origin and forming the portion of a group, each of which represents a theoretical blast for an index i. To each of them should correspond a straight line which, for the same index, represents the real blast, and the segment parallel to the V axis included between i_t and i_v measures the necessary excess of blast. The excess will be almost zero for complete combustion to CO and it will be infinity for complete combustion to CO_2 which is impossible to realise practically.

TABLE I.—*Runs with Measured Blast.*

No.	D	A	C″	W	X″	V
84	1,200	1.131	0.1940	1.00	0.171	0.97
57	800	0.503	0.0975	0.66	0.194	1.32
86	1,300	1.327	0.2916	2.41	0.222	1.88
81	1,000	0.785	0.1750	1.35	0.223	1.72
20	600	0.285	0.0733	0.63	0.257	2.21
9	500	0.198	0.0622	0.58	0.314	2.90
72	900	0.636	0.2080	2.00	0.327	3.14
54	800	0.503	0.1370	2.00	0.272	3.93
65	850	0.567	0.0725	0.90	0.127	1.58
8	500	0.198	0.0333	0.41	0.166	2.05
66	850	0.567	0.0973	1.25	0.171	2.20
23	600	0.285	0.0550	0.70	0.192	2.48
83	1,200	1.131	0.2220	2.50	0.196	2.21
37	700	0.390	0.0760	0.92	0.194	2.36
77	1,000	0.785	0.1750	1.35	0.223	2.54
71	900	0.636	0.1666	2.00	0.261	3.14
56	800	0.503	0.0778	1.25	0.153	2.50
53	800	0.503	0.1280	2.00	0.254	3.93
18	600	0.285	0.0760	0.75	0.267	2.63
47 bis	700	0.390	0.1230	1.20	0.315	3.08
0	650	0.338	0.0733	1.04	0.216	3.10
	650	0.338	0.0733	0.91		2.71
96	420	0.138	0.0165	0.114	0.119	0.82
97	600	0.285	0.0350	0.280	0.122	0.99
92	600	0.285	0.0860	0.825	0.300	2.88
93	550	0.237	0.0770	0.750	0.325	3.16
94	815	0.522	0.1160	1.510	0.222	2.89
95	740	0.430	0.0930	1.250	0.216	2.90

* Italian Exchange Paper presented at the Polish International Foundry Congress.

† Associazione fra gli industriali meccanici ed affini.

The general equation being known, it is possible to construct any straight line for the theoretical blast, and three straight lines are known for the real blast:—

$i_v = 0$ which coincides with $i = 0$, $i_v = 0.7$, which is no other than $X'' = 0.1$ V and $i_v = 1$ which coincides with the V axis. There is therefore a definite relationship between these two groups of straight lines, and a simple graphic construction suffices for finding the straight line of the real blast corresponding to a straight line of the given theoretical blast. It is thus possible to draw the straight lines $i_v = 0.8$, $i_v = 0.9$, etc., starting from the origin with ever-increasing excesses.

A characteristic point of a run falls within a certain region of the diagram. Its position relative to the straight lines of the real blast provides information regarding the nature of the run and its probable index. It is interesting to note that the points of runs are very rarely on a straight line; in other words, it is rare to find a number of runs having the same index. The runs found in practice have different indices and are arranged on curves in passing from one to the other.

It may be asked what is the invariant of these curves (Fig. 1), or what amounts to the same thing, what is their significance? They can only represent the variation of X'' with V, each for a given resultant of all the factors, excepting the blast, which determine the combustion.

The question may be raised:—Why do the majority of runs observed arrange themselves in two curves, in other words why are there two statistically preponderant invariants? The fact is explained by the existence of two main tendencies followed by cupola operators, two schools of foundrymen:, those who aim at economic operation, and those who underestimate this factor and keep in view only the high temperature of the cast iron. Each adept of one of the two opposite principles endeavours to cause the different factors to combine to form a certain resultant, and by repeated failures and experiences, they almost all agree on a certain rate of working, that is to say, one or the other of the two, and the cases in which this rate is exaggerated in either direction are rare.

In order of importance, these factors are the following:—The height S of the bed of coke of the charge, the ratio of the charge of metal to that of coke (proportional to the reciprocal of K, ignoring additional charges of coke), the pressure p and the height of the column h.

The Bed S

Observations made on 97 cupolas, although their accuracy is not absolute, show a certain regularity in the correspondence between the values S and X''. A classification of results according to the values of the latter variable shows that of 35 cases of low X''—between 0.086 and 0.200—in 29 cases S was less than 160 mm. In the above-mentioned hypotheses, this figure of 160 mm. represents a charge of C of 75 kg. per sq. metre of furnace, which with a suitable blast ensures a possibility of a run with K = 8, that is to say, an index of 7:3 ($i = 0.7$). Between $X'' = 0.200$ and 0.300, on the contrary, of 44 cases there are only 9 in which S is less than 9. Above $X'' = 0.300$, of 14 values, there is only one case of S being less than 160.

The bed S thus plays a certain part in combustion in the cupola, and this is in agreement with the views of the classical theory of Le Chatelier,[4] according to which the distance of the zone of complete combustion from the tuyeres depends on the size of the pieces of coke. The column which lies above is merely a kind of incandescent grate and only plays a very small part in combustion. This part is not quite nil, because the 93 observations made definitely show that the coke of the bed which burns during one operation of the cupola (that is to say in three, four or even more hours) is several hundreds of kilograms, but the portion which is consumed with a charge, that is, in 6 or 7 min., is at the most 15 per cent. of that charge. This explains—without, however, justifying it—the optimism of foundrymen and many writers who completely ignore the bed and only look at the consumption of the charge. The values of X'' ought therefore to be increased by this portion of the bed which is consumed (extra charges of coke, if any, are allowed for in the value of K), but the conclusions of this investigation, which is merely tentative, will only vary slightly in the case of this correction in the absence of exact particulars regarding the duration of the operations.

The thickness S is therefore one of the important factors affecting the rate of combustion. A mean value of S of 160 mm. gives rise to the index 0.7 if the blast is suitable. A lower value of S would tend to give still better indices. Higher values of S favour the reduction $CO_2 + C = 2\,CO$, therefore a higher coke consumption for the same blast.

Charge of Metal and Coke

The equilibrium between CO_2 and CO depends upon the temperature at which the reaction is to take place. Any chilling effect favours the formation of CO_2. If this effect is slight, the reduction reaction predominates and the CO increases[1 5 6]. The charge of metal is a chilling agent, and according to the ratio $\frac{P}{C}$ the coke will appear more or less disposed to burn to CO_2 in the zone of complete combustion. Full metal charges (900 kgs. per sq. m. of furnace, at least for diameters of 700 mm., accompanied by normal charges of coke of 72 kgs. per sq. m.) favour good combustion. Light charges only chill slightly and CO will predominate. The importance of this influence of the charge is of the same order as that of the bed S.

The pressure p and the height h, on the contrary, only play a secondary part. The pressure p plays only an accessory part during the combustion of the coke. A suitable value of p favours the penetration of the blast to the centre of the furnace and consequently may be considered as a factor affecting the quantity of CO_2. Higher up, the expansion of the gases, attaining six or seven times the original volume of the cold blast, renders the influence of the pressure almost negligible.

The height h also is of accessory importance for combustion by favouring the formation of CO by reduction, if it exceeds a certain height. For the sizes of coke usually employed, the normal value of the height h varies between 800 and 1,000 mm.

If these factors had the same importance, and if it was possible to ascertain exactly the law expressing the influence of each factor, then denoting by I_s, $I_{\frac{P}{C}}$, I_p, I_h the performance indices, each of which would be checked by assuming the others to be equal to 0.7 considered as normal, it would be necessary to obtain their product, and the fourth root of the latter would be the geometric mean of the four values and hence the probable resultant I_r.

TABLE II.

(a) Partial invariants and coefficients of correction of S and $\frac{P}{C}$

s	I_s	$\frac{P}{C}$	$I_{\frac{P}{C}}$	p		h	
100	0.85	14	1.00	0.6	1.00	800	1.00
130	0.77	13	0.90	0.6	1.00	800	1.00
160	0.70	12	0.90				
190	0.62	11	0.80				
220	0.55	10	0.80				
250	0.47	9	0.70				
280	0.40	7	0.60				
		6	0.60				

(b) Curve 1.

No.	S	I_s	$\frac{P}{C}$	$I_{\frac{P}{C}}$	$I_s \cdot I_{\frac{P}{C}}$	$\sqrt{I_s \cdot I_{\frac{P}{C}}}$	p	h	I_r
84	100	0.85	10.0	0.80	0.68	0.82	0.42	900	0.55
57	155	0.72	7.5	0.65	0.47	0.69	0.45	?	?
86	175	0.67	9.7	0.78	0.52	0.72	0.55	800	0.55
81	195	0.62	7.1	0.62	0.38	0.61	0.50	1,500	0.50
20	195	0.62	8.0	0.70	0.43	0.66	0.75	1,000	0.57
9	163	0.69	7.0	0.60	0.41	0.65	0.78	950	0.57
72	190	0.62	7.6	0.65	0.38	0.61	0.80	900	0.57
13	234	0.51	8.3	0.73	0.37	0.61	?	?	?
97	113	0.81	?	?	?	?	?	600	?
92	250	0.47	9.9	0.79	0.37	0.61	0.90	600	0.61
93	252	0.47	10	0.80	0.38	0.61	0.90	1,000	0.58

(c) Curve 2.

65	110	0.83	14	1.00	0.83	0.91	0.50	?	?
8	134	0.76	12.5	0.90	0.68	0.82	0.55	500	0.75
66	170	0.67	14	1.0	0.67	0.82	0.50	1,300	0.75
23	150	0.72	10.0	0.80	0.57	0.76	0.50	?	?
83	150	0.72	12.5	0.90	0.68	0.83	0.50	500	0.75
37	140	0.75	9.2	0.73	0.55	0.74	?	900	0.70
77	80	0.85	14.0	1.0	0.85	0.91	0.60	?	?
71	160	0.70	7.7	0.67	0.47	0.68	0.75	900	0.68
56	123	0.79	14.0	1.00	0.79	0.75	?	?	0.70

The importance of p and h, however, is far from being equal to that of the first two factors. It is proposed, therefore, to confine consideration to obtaining the geometric mean (the square root of the product) of I_s and $I_{\frac{P}{C}}$ having fixed a probable law of their classification with the values of S and $\frac{P}{C}$ and thereby determine coefficients of correction by means of the values of p and h.

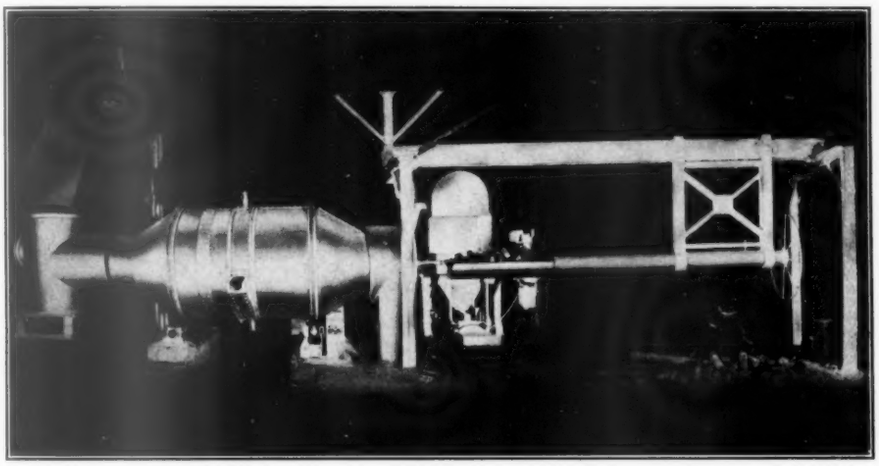
Merely by way of experiment, Table II shows the values of I_r on the basis of the variations of the two principal factors. It will be seen from this table that there is a constant of almost 0.55 for the curve "1" and one of nearly 0.75 for the curve "2." The curve "1" never cuts

(*Continued on page* 186.)

A New Pulverised-Fuel-Fired Rotary Furnace

A SIMPLIFIED DESIGN

Although rotary furnaces are well established in the British foundry industry—probably more so than in any other industrial country—the appearance of a new system will be welcomed, especially when it exhibits characteristics of a unique character. The writer recently had the privilege of inspecting a new installation at the works of Foundry Equipment, Limited, at Leighton Buzzard. This furnace, which is covered by Patent Application No. 33,035, is characterised by two main features: (1) It is designed to use commercial supplies of pulverised fuel, that is, no pulverising plant is normally supplied with the plant, and (2) as adequate heat for the melting of cast iron is generated, no recuperators have been included. Obviously, should a user decide to instal a grinding plant or include a recuperative system, the design is such that they could be easily incorporated.



PULVERISED-FUEL-FIRED ROTARY FURNACE, BY FOUNDRY EQUIPMENT, LIMITED, WITH CHARGING EQUIPMENT.

Another feature which is quite new is a hydraulic tilting arrangement so that the furnace can be slagged off.

The fuel, a bituminous coal, is supplied in bags in the form of powder specified to be of such fineness that 95 per cent. passes through a 200 mesh. These bags are stored on an elevated platform erected at a suitable height for charging into a hopper. The base of this hopper carries a closure consisting of an endless-belt feed, positively and automatically controlled so that a definite quantity is sucked by an electrically-driven fan into the burner. Another fan provides the necessary air. This particular furnace of 2 to 2½ tons capacity is the No. 2 size, and carries a body with an external diameter of 5 ft. 5 in. lined down to 3 ft. 7 in., and 12 ft. 10 in. overall length. The nose is fairly blunt to give a baffling effect. At the exit end is an exhaust elbow, and here sufficient heat escapes to warrant connecting up with the flues of mould or core-drying stoves, and, indeed, such a practice is undertaken at Leighton Buzzard. Moreover, it is worth envisaging by future users.

The furnace at the time of the visit had made a matter of thirty heats and the lining was still untouched. Ample temperature was generated for the shanking of the metal for thin-sectioned castings. The furnace is rotated so that one complete revolution per minute is effected. The drive, which is controlled by conveniently placed push-buttons, is by coupling through gearing to rollers upon which the body of the furnace rests. This drive is at the firing end, and centrally positioned at this end is a hydraulic jack, whilst the bearings at the opposite end are so designed that they act as a pivot. For slagging, the refractory-lined exhaust elbow, mounted on wheels running on rails, is pushed away, and the furnace is tilted. The designers very rightly attached major importance to this innovation, as providing a means for the addition of alloys which gives every possible assurance of the highest yield and consequently a control of composition of a very high order. This facility, coupled with mixing by rotation, should ensure a maximum control of composition and equal distribution of the elements.

The furnace shares with all rotary furnaces the ability to maintain temperature during prolonged casting periods, even to the extent of pouring back metal for regaining temperature, whilst the rotary principle makes for economy in operation and regularity in composition.

The furnace is charged by a rotatable scoop suspended from a steel bridge. The scoop is the working length of the furnace, and the horizontal movement enables it to be brought well back from the furnace to allow of ample working space around it. It is manually controlled throughout.

As the foundry which the furnace serves at Leighton Buzzard is of modest dimensions, the output is insufficient to warrant continuous operation. Sufficient work, however, has been done to show that the first cast starting from cold takes 2 hrs. 50 min., and thereafter 2 hrs. 15 min. The fuel consumption for unalloyed grey-iron castings is of the order of 5 cwts. per ton of metal melted for first melt, and for the second and thereafter 4 cwts.

At this stage it is impossible to forecast the length of life a lining will sustain, but at the end of thirty heats it was certainly in a remarkably good condition. A Belgian refractory has been used in this case, but arrangements have been made to try out British material for the next lining.

A range of furnaces has been designed covering capacities from 10 cwts. to 5 tons.

The writer wishes to express his gratitude to the directors and management of Foundry Equipment, Limited, for their kind collaboration in the preparation of this article.

THE THIRD Conference on Industrial Physics is being arranged by the Institute of Physics to take place in Leeds from March 23 to 25 next under the presidency of Prof. R. Whiddington. The subject of the Conference is to be "Physics in the Textile Industries."

Production of Cast Iron

TWO NEW PATENTED PROCESSES

In response to a request for details of two patents granted to him and the Austin Motor Company, Mr. J. J. Sheehan has sent us the following description:—

High-duty cast irons are characterised by low total carbon and low silicon content. There is considerable difficulty in casting this material, and there is also the risk of white metal on thin sections of the castings. Some of the casting difficulties may be overcome by superheating the metal. The liability to white iron may be minimised by the addition of nickel-silicon shot or by other inoculating processes.

The effects of inoculation are also rendered more certain when the metal is at an elevated temperature. It is usual to obtain this extra temperature by duplexing in an electric furnace or in a heated receiver. It is possible, however, to melt and superheat in the same furnace. The economy in doing so is evident.

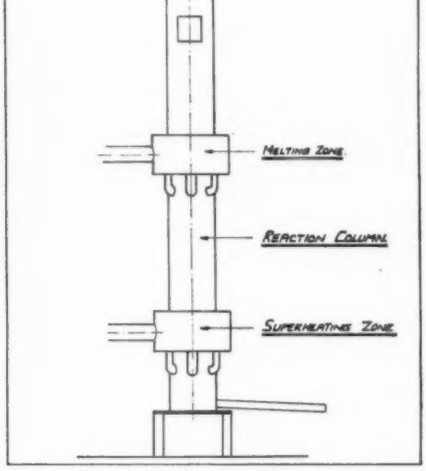


FIG. 1.—CUPOLA OF PATENTED DESIGN, WITH MELTING AND SUPERHEATING ZONES SEPARATED BY DEEP REACTION COLUMN.

The cupola furnace in which these conditions are possible is illustrated in Fig. 1, and the design is covered by Patent No. 494,511. It is also possible with the high temperatures produced within the furnace to reduce silica to silicon in the presence of iron. This is the reverse of what ordinarily occurs in a cupola. The cast iron produced under these reducing conditions is superior to iron produced under severe oxidising conditions. This improved method of production is covered by Patent No. 494,306.

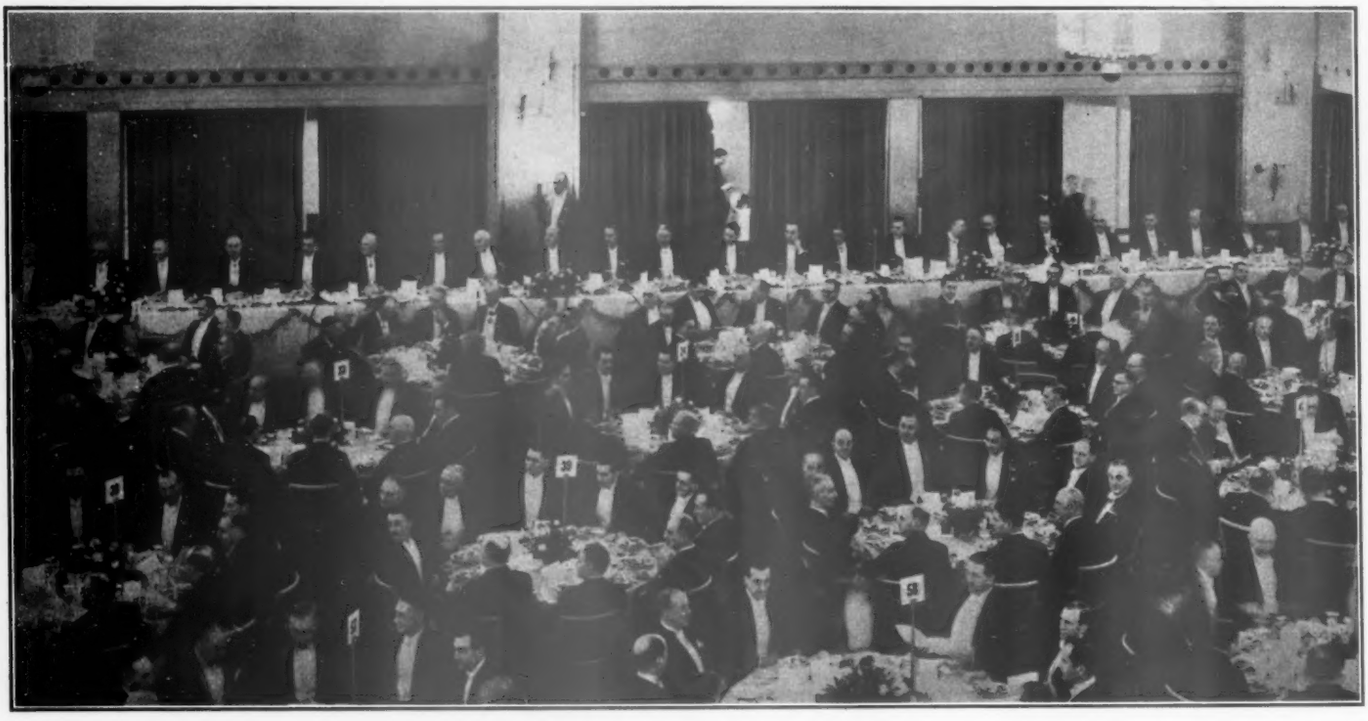
The general idea underlying both patents is the production of a deep high-temperature reaction column in which it is possible to utilise both time and temperature in producing reactions that require both, without interfering with the continuity of operations which renders the cupola type of furnace so valuable.

INTERNATIONAL COMBUSTION, LIMITED, have recently received several important orders for watertube boilers for the foreign and home markets. Repeat orders have been received from, among others, the South African Torbanite Mining & Refining Company, Rotherham Corporation, and the City of Leeds Electricity Department. The material handling division of the company has obtained several orders, among them one from the County of London Electricity Supply for a Beaumont drag scraper plant for the coal store at Barking Power Station.

The British Iron and Steel Federation

ANNUAL BANQUET IN LONDON

The Annual Banquet of the British Iron and Steel Federation was held at Grosvenor House, Park Lane, London, last Thursday evening, Mr. R. S. Hilton presiding. The principal guests were the Rt. Hon. Sir John Simon, G.C.S.I., G.C.V.O., K.C., M.P. (Chancellor of the Exchequer), and the Rt. Hon. John Colville, M.P. (Secretary of State for Scotland). Other guests who accepted invitations included the Rt. Hon. the Earl of Dudley, M.C. (President, Iron and Steel Institute); Col. Sir Charles Wright, Bt., K.B.E., C.B. (Past-President); Sir Edward J. George (Past-President); the Lord May, K.B.E.; Engr. Vice-Admiral Sir George Preece, K.C.B. (Engineer-in-Chief of the Fleet); Comdr. Sir Charles Craven, O.B.E., R.N. (Vice-President); Sir Stanley Goodall, K.C.B., C.B.E. (Director of Naval Construction); Mr. S. Summers (Vice-President); Mr. John Craig, C.B.E. (Past-President). The company numbered upwards of 1,500 members and guests.



BRITISH IRON AND STEEL FEDERATION BANQUET.

SIR JOHN SIMON, K.C., M.P. (Chancellor of the Exchequer), proposing the toast of "The Iron and Steel Industry," said the British Iron and Steel Federation was founded just over 20 years ago, at the time of the Armistice. We had at that moment in this country an iron and steel industry which had greatly expanded under the necessities of war and which was singularly ill-balanced and ill-distributed for the purpose of peace. We had, at the same time, in foreign countries, rival industries which had increased outputs stimulated by the circumstances of war and who were indeed anxious to seize any opportunity of pushing their trade into any market that remained open. After an interval of feverish and short-lived post-war boom, trade fell into a situation of anxiety and regression which extended for 10 years.

After that black period of depression, hope returned in 1932. The Import Duties Advisory Committee, in their first Report, made in April, 1932, stressed the special need of the iron and steel industry for early and particular consideration. They proposed, for the time being, the protection of a duty of 33⅓ per cent., and they called for a scheme to be formulated under which our great British industry could hope to recover. The duties were continued for two years, a temporary duty, and, to use the language of the Committee, "subject to satisfactory progress being made in the preparation of a scheme of reorganisation and of putting the approved scheme into force."

Finally, Sir John Simon said:

"Before I sit down, you would expect me to say one word on the more general political and international situation. I feel, and I suspect that you feel, there is an increasing sentiment all over the country that the prospects of peace are becoming more secure. We are all earnestly hoping that that feeling may be well founded, and there is a wide appreciation, I am sure, of the fact that this feeling is largely due to the policy so steadily and so persistently pursued by the Prime Minister and the Foreign Secretary. If you challenge me for evidence, I would say that this growing confidence is in the atmosphere. It is influencing, I think, the City. It is giving some encouragement, I hope, to traders. It certainly is sustaining Ministers when they have to propose to the country measures of the magnitude and importance of those that I have to place before the country this week. You know the famous line, 'If hopes were dupes, fears may be liars,' and undoubtedly many of our hopes after the war have been disappointing; but this impression that things are better is due, as I conceive it, to a combination of causes. Let us make a short list of them.

"It is due to the knowledge that Britain is growing stronger every day. It is due to the evidence, plain to all the world, that we are prepared to shoulder any and every burden that is necessary to make us secure. It is due to the close and warm understanding existing between this country and France. It is due to our good relations—and they never were better—with the United States of America. It is due to the prospects of an early ending of the Spanish War without that war extending beyond the boundaries of Spain; and, above all, I think it is due to a feeling of confidence and trust in and admiration of the determination with which Mr. Chamberlain has pursued his policy of promoting better understanding with other States, whatever their form of Government may be, and to the coolness and firmness with which he has held to his course during recent months.

"Sometimes in the past the British Government has been charged with having, as it was alleged, failed to make its position clear to foreign nations. Well, I speak on behalf of the Government when I say this; we wish to avoid that charge, and without challenge to others and in no aggressive spirit, we feel it our duty to leave no man and no Government in any doubt as to where this country stands. We are whole-heartedly devoted to peace, and Britain is putting forth all her efforts and all her energy to secure it and maintain it. Our rearmament, formidable as it is, has no aggressive purpose, and there is no country and no sane man in the world that imagines that it has. It will never be used wantonly to disturb the peace of the world, and we would welcome the day when a general reduction of armaments could effectively be secured by international agreement, agreement which would enable labour and capital in all lands to be devoted more completely to works of peace.

"But in pursuit of peace we shall not be prepared to surrender any of our vital interests. The Prime Minister has recently made emphatic declarations—and it is useful that we should recall them to-night—which have shown most clearly, more clearly than ever, how we regard the vital interests of France as bound up with our own, and all over the world it is right that it should be understood that our country—the whole country—supports the Prime Minister in these declarations.

"I have ventured to detain you to make a simple declaration which I think is timely and justified. These facts are simple facts known to all of us here at home, and there is no reason

whatever why we should not make them equally plain to all the world. They are simple facts which all the world can understand, and on the basis of these fundamental facts which I have tried to state, we shall do our utmost to contribute, in co-operation with all men of goodwill, to the spread of confidence and good understanding in Europe and throughout the world.

"I hope you will not think I have done wrong in passing a little outside the immediate subject of my toast, but these fundamental considerations have much to do with the prosperity of your great British industry, and keen as competition may be and engrossing as business may become, there is no one of you or no one of us who does not put these considerations, essentially for the future of the British race, far in front of any smaller or personal considerations whatever."

The President's Speech

MR. R. S. HILTON (President of the Federation), who responded to the toast, observed that relations between the industry and its customers were of a cordial character. The interchange of information and technique and the broadcasting of research had perhaps never been more thorough than at the present time; and that co-operative spirit surely was one of which the industry as a whole might well be proud. In that connection the President paid tribute to the Department of Scientific and Industrial Research, which had done so much to help on the good work of disseminating technical knowledge.

There was no necessity before a British audience to stress the need for an adequate export policy. But if we were perfectly truthful with ourselves we must confess that during the last two years, when the whole of the steel output of this country was earmarked for home consumption, the export market had had to take second place. Conditions had now altered, and it was one of the problems to which the industry must apply itself during the next few years.

We must remember that nearly all foreign countries which, before the Great War, were purchasers of our steel, had found that they could produce the steel which in the past they had had to import largely from this and other countries, and they had put down their own iron and steel plants. That applied also to our Empire overseas. We could not blame either our own or other people for wishing to exploit to the full the advantages they possessed; but it looked as though in the future the market in certain steels which we had enjoyed in the past on the export side might be lost to us, and, therefore, we had to find other uses for that steel, because the production must go on.

One thing in regard to which we could take to ourselves some comfort was that the quality of British steel could still be maintained, and it was to that quality rather than to quantity that our export trade must look in the future. Quality meant brains; and the country which in the past had led the steel industry of the world in regard to brains could still make a good showing in that field. We must call for a greater output from our research organisations, we must improve the quality of our steel-making staff, and, perhaps above all, we must secure the co-operation of labour. He believed that, once labour understood what was required, they would take their full share of responsibility in keeping our steel industry in the forefront of progress.

The confidence which he had mentioned earlier had encouraged the industry to spend money on improving and extending their plant, and it was calculated that during the last five years something like £40,000,000 had been spent in that connection. That expenditure was still proceeding, for the steel industry had a re-armament programme similar to the rearmament programme of our national defences.

While the industry had done so much during the last five years, there was still much to do. Perhaps one of the fascinations of industry was that organisation was never complete, and, therefore, one could never sit back and say, "I have done my job." The task which the Federation had set itself was no light one; but if the industry could be assured during the next few years of true comradeship inside it and fair play outside, then the Federation would be a credit not only to the industry, but also to the great country to which we belonged.

Toast to the Guests

MR. SPENCER SUMMERS (chairman of the Tariff Committee of the Federation) proposed "The Guests," and coupled with the toast the name of the Rt. Hon. John Colville, M.P. (Secretary of State for Scotland). He pointed out that among the most important of the guests were also those connected with the distributing and consuming end of the industry. He trusted that they had not felt any undue reluctance in accepting the invitations they had received, as they might well have done, realising that owing to the very drastic cut in prices which was accepted at the beginning of the year it might appear that the manufacturers were so impoverished as to render necessary some reduction in the standard of hospitality to which their guests had been accustomed in the past! The industry was proud of being one of the pioneers of voluntary control in industry; but, nevertheless, it attached importance to certain traditions, and that fact had enabled members of the Federation to overcome any embarrassment in contemplating the entertainment of so many guests.

The Federation was particularly fortunate in being able to welcome both the Chancellor of the Exchequer and the Rt. Hon. John Colville. In coupling Mr. Colville's name with the toast, he recalled that as head of the Department of Overseas Trade he had had opportunities of knowing some of the difficulties with which the industry was faced in export markets, and of renewing some of those friendships he had made formerly in the steel trade. Now that his sphere of interest had been transferred to the wilds of Scotland, he would not forget his English friends. In thinking of steel, one could not help thinking of the name of Colville; and in thinking of the name of Colville one could not help thinking of Scotland. Members of the steel industry had learned to respect and admire the name of Colville, and it was only right that they should take the opportunity of saying how much they respected and admired that name also in the field of politics.

THE RT. HON. JOHN COLVILLE, M.P. (Secretary of State for Scotland), responding, and in returning thanks for the hospitality extended to the guests, said they would agree with him that they had reached the "elastic limit" some time previously!

The proceedings terminated with the singing of the National Anthem.

D

BRITISH IRON AND STEEL FEDERATION BANQUET.

Some Notes on Making High-Duty Cast Iron*

By J. H. WILLIAMS, B.Sc., F.I.C.

For all practical purposes, one may roughly attribute the advent of cast iron of high tensile strength to the period of the Great War of 1914-1918. Steel additions to cupola charges with the object of improving the strength of cast iron had, however, been made before that time, but the results were frequently unsatisfactory. As a result probably of these early experiments which proved so unfortunate, there exists even to this day a distinct distrust among many older ironfounders against the addition of steel to the cupola.

The author has a vivid recollection of the dismay and incredulity with which a suggestion to incorporate 30 per cent. of steel scrap in a cupola charge was received about 7 years ago by an executive in a fairly large foundry. It transpired that, at some date previously, a small quantity of steel (somewhere about 10 per cent.) had been added as part of a charge to a cupola with disastrous results. Since then, any scrap of steel had been religiously kept out of any charge. However, this foundry was persuaded to try once more the use of steel scrap under good melting conditions and obtained satisfactory results. There is no doubt that in the early days of experimenting with steel scrap or wrought iron in the cupola, considerable difficulties were encountered owing to poor cupola practice and the absence of sufficient manganese in the charge.

Many will also remember when the accidental addition of a piece of white iron to a grey iron charge was regarded as calamitous. Possibly this arose from difficulties which manifested themselves when common white iron formed an appreciable fraction of the charge. This was quite likely when the properties of white irons were not so well known as at the present time. The usual high sulphur and low manganese contents, combined with the "inherent property" of these irons to contain a high percentage of oxides in the form of a very finely divided silicate slime, may readily account for the unsatisfactory results and led to the conclusion that white iron of any class or in any quantity spelt ruination of the metal.

Lanz-Perlit Process

One may date the regular use of steel scrap to cupola charges to the post-war period when the Lanz-Perlit and the Emmel processes were introduced. It is interesting to note that Hurst read a Paper before the Lancashire Branch of the Institute of British Foundrymen on "Semi-Steel" in 1915, though he would probably modify some of his conclusions at the present time. About the same time, Hurst made a synthetic pig-iron from an all-steel mix.

McRae Smith, also some years ago, made a synthetic pig-iron in a cupola, with which he made castings direct, from an all-steel mix with 2 per cent. silicon added as briquetted 45 to 50 per cent. ferro-silicon and 1 per cent. manganese as briquetted carbon-free ferro-silico-manganese. The resulting iron contained 1.78 per cent. silicon and 0.87 per cent. manganese, so that the oxidation losses were low considering the nature of the charge.

When the author was in Sweden three years ago he noticed that the principal Swedish makers of malleable iron always melted down all-steel charges plus ferro-silicon and ferro-manganese additions. Their only complaints were the heavy oxidation losses in silicon and manganese on melting and the variability of those losses.

The Lanz-Perlit is a hot-mould process for making high-duty cast iron of about 20 tons per sq. in. tensile strength. Essentially it consists of adjusting the composition of the metal to the average thickness of the section and the mass of the casting, and pouring into a sand mould which has been heated to a given temperature, usually about 400 deg. C., which has been determined experimentally. The iron is low in silicon, so that if cast in ordinary cold moulds it would solidify in the mottled or even in the white form in the thin parts of the sections. Owing, however, to the slower and more equable rate of cooling throughout the light and heavy sections, all parts solidify with a close-grained pearlitic structure.

It is contended that the tendency for graphitisation in the thin sections is assisted by the hot mould walls being close together and that the low silicon content modifies that reaction in the thick sections. In passing, it is interesting to note that E. Longden, on melting down charges of white pig-iron of the requisite composition for the Lanz process, frequently obtained mottled castings, but on "coming down," as he termed it, by charging into the cupola a grey iron with steel scrap to give the same composition in the molten iron, all the castings were grey and pearlitic. It is possible that some "inherent property" of the white pig-iron was responsible for the mottled castings. The advantage of the Lanz-Perlit iron lies in its good heat-resisting properties owing to the low silicon content; otherwise, as a method of producing high-tensile cast iron it would probably by now be out of date.

Emmel Process

The Emmel process has now gone or has been merged in later processes. It simply consists in using a high percentage of steel scrap in the cupola charges along with high-silicon pig-iron and common ferro-manganese or spiegel additions. The charges are run down under careful control of the cupola, but in spite of this the process was liable to give erratic results. The Emmel process employed very high percentages (60 to 80 per cent.) of steel scrap in the charge, but with improvements in cupola melting it was gradually discovered that iron with a tensile strength of 16 tons or 18 to 19 tons per sq. in., could readily be made with much smaller steel additions so that the wear and tear on the cupola lining was reduced. For instance, some 10 years ago, a foundry with which the author was well acquainted was easily obtaining 16 tons tensile strength from charges containing 30 per cent. steel scrap and the cast iron had 2 per cent. silicon and 0.8 to 0.9 per cent. manganese. With 40 per cent. steel scrap and the iron averaging 1.6 per cent. silicon and 0.8 to 0.9 per cent manganese, the tensile strength rarely dropped below 18 to 19 tons. High tensile strength was therefore not gained by having an unduly low silicon content in either type. In both cases the total carbon ran out about 3.1 to 3.2 per cent., and phosphorus was moderately low at around 0.4 per cent. These factors, combined with good melting practice, were the primary ones in obtaining such good figures for tensile strength.

The recent report of the Cast Iron Sub-Committee upon the Properties of Grey Cast Iron may lead one to infer that irons of the highest strength, *i.e.*, those classed as Grade 3 (22 tons and over), require the use of special processes involving inoculation, superheating and so on, but such is not the case, as some foundrymen are probably aware. Admittedly these special processes ensure certainty and in general allow the metallurgist more latitude in his mixing.

Nickel Cast Iron

The author has obtained over 22 tons, tested by the 0.875-in. bar, by melting down steel scrap and white iron with silicon and manganese added in the form of silicon briquettes and carbon-free manganese briquettes. The white iron must be a refined iron, which the author prefers to make himself by melting down a good pig-iron and steel scrap with extra manganese and desulphurising with soda ash in the ladle. Ordinary white iron bought outside cannot be relied on. It may or may not serve the purpose. By this means the total carbon is reduced to 3.0 per cent. or more often less. One may come down to 2.6 per cent. total carbon with such charges, but this is rather too low, because with very low carbon trouble may be experienced from excessive shrinkage.

With carbon at 3 per cent. or less the influence of silicon, as is well known, has no appreciable effect on the tensile strength, although it affects the hardness and machinability, and it has been found that silicon can vary from 1.6 to 2.0 per cent. without the tensile strength falling below 22 tons. Greater certainty can be had by making a ladle addition of carbon-free ferro-silico-maganese. Again, a tensile strength of 22 to 24 tons can be readily obtained if 1.5 per cent. of nickel is alloyed with a suitable charge. For example, such an iron can be produced by melting down 75 per cent. steel scrap with 25 per cent. of close-grained grey pig-iron having, say, a silicon content of 1.2 to 1.6 per cent., adjusting the mix with ferro-silicon and ferro-silico-manganese and adding 1.5 per cent. nickel in the form of "F" nickel ingots. A typical analysis of the metal is as follows:—T.C, 2.78; Si, 1,98; Mn, 0.76; S, 0.117; P, 0.20; Ni, 1.42 per cent.

This metal has been run successfully in East Anglia giving 23 to 24 tons tensile, using Carron 1.6 per cent. silicon pig-iron. Close-grained low-phosphorus pig-iron, good steel scrap and careful melting are essential for success. The mix must be melted down steadily, neither too slowly nor too fast, and the most suitable height for the coke bed above the tuyeres may require a little experimenting.

Cupola Practice for High-Duty Irons

It is perhaps needless to remark that the cupola must be hot before bringing down the first charge of high-tensile iron. Either a couple of preliminary charges, say, one of common iron and one of steel-mix iron must be run through the cupola to heat it up, or the high-tensile iron may be made after the ordinary work has been cast by draining the furnace, again making up the bed, and following with the high-steel charges. Both methods are satisfactory.

The best weight for the charges lies between 7 and 10 cwts. If more than one charge is required, say four 8-cwt. charges to be received in one ladle, the whole of the nickel is added to the first charge or may be divided between the first two charges. This is done to ensure obtaining the maximum yield of nickel, the last charges acting as washes through the coke bed. Incidentally, the same procedure is very useful for nickel-chromium cast iron, all the nickel and chromium being added to the first charge. Manganese, however, should be added individually to each charge.

It must not be forgotten that high-tensile cast iron has a limited range of freezing and is very easily oxidised; for these reasons it must be poured as quickly as possible. The molten metal can be thoroughly deoxidised by means of carbon-free ferro-silico-manganese, and MacPherran has recently recommended the addition of 3 lbs. of this alloy to 1,000 lbs. metal in the ladle. This de-oxidising agent has, however, been employed by a few foundrymen

* Abridged from a Lecture delivered before the East Anglian Section of the London Branch of the Institute of British Foundrymen at Ipswich.

in this country for a long while. About 0.3 to 0.4 per cent. of ferro-silico-manganese may be added in pieces, the size of small shot, to the ladle, or better in the briquetted form to the charge in the cupola.

Nickel-Molybdenum Irons

Cast iron of very high tensile strength may also be made in a similar manner, by the use of combined additions of 1.5 per cent. nickel and about 0.3 per cent. molybdenum; but the author has had no experience of this alloy iron. Also, molybdenum is mainly added for the increased impact resistance it confers on cast iron, and its high price militates against its use simply for raising the tensile strength of cast iron.

Nickel-Chromium Irons

Nickel-chromium cast iron with total carbon around 3.0 to 3.1 per cent. also yields a high tensile strength of 24 to 26 tons per sq. in. A charge of 60 per cent. steel scrap with 40 per cent. refined white iron and remelts usually gives satisfactory results from a good cupola. Extra silicon and manganese must be added to adjust the composition. If the total carbon drops below 3.0 per cent., a proportion of close-grained grey iron can be incorporated in the charge. The nickel and chromium must be adjusted in the ratio of 3 to 1 in order to neutralise the hardening and embrittling influence of the chromium. Silicon should be maintained at about 2 per cent.

The nickel-chromium irons require great care to produce, as it is of utmost importance to obtain a uniform distribution of the chromium. It is not advisable to use ordinary ferro-chrome in lump form. Either the chromium should be added to the cupola charge as chrome pig-iron or chromium briquettes or to the ladle as powdered ferro-chrome. The carbon-free grade is best for ladle additions in spite of its higher cost, as it seems to give a more homogeneous mixture.

The combination of chromium with nickel is, however, unnecessary for the purpose of obtaining 22 tons tensile cast iron, as the same result may be obtained more easily and cheaply from a nickel iron.

In all the above cases, the alloy additions of silicon, manganese, nickel and so on, required to adjust the charge to the requisite composition, have been added to the cupola. Nickel may be added in the form of "F" nickel shot to the stream of metal at the cupola spout, but it is much better to add it directly to the charge in the furnace, because one obtains a more homogeneous solution and no heat is lost by the addition of a cold metallic substance to the molten metal. The loss is very small as nickel undergoes no oxidation. The only slight disadvantage is the tendency of nickel to absorb hydrogen and pick up a little sulphur.

The author has had no experience in making very heavy castings in high-duty iron, but in a Paper published in the Transactions of the American Foundrymen's Association in 1937, MacPherran states there are no foundry reasons which limit the size of the castings produced and his firm (Allis-Chalmers Mfg. Company, Milwaukee, Wis.) have made them up to 37 tons in weight. One would imagine, however, that the number and size of the heads required to compensate for the heavy shrinkage would require some thought, and the cost of removing them would be somewhat expensive.

Inoculation Processes

Of the special processes involving inoculation, the Meehanite and the Ni-Tensyl are the best known. In the Meehanite process a high percentage of steel scrap is incorporated in the charge, which is adjusted to the correct composition for silicon and manganese and a final addition of silicon is made to the ladle in the form of calcium silicide to yield a dense, pearlitic grey iron.

The Ni-Tensyl process similarly employs a high percentage of steel scrap along with a close-grained pig-iron, with which a certain proportion of silicon in the form of a high-silicon pig-iron or silicon briquettes is added. Ferro-manganese or manganese briquettes are also added to run the high steel-mix and increase the manganese content of the charge.

Nickel is added either to the charge or to the ladle, but again it is better to incorporate the nickel in the charge. On tapping, the remainder of the silicon required is added to the stream of metal at the spout. In subsequent runs a small proportion of remelts is added to the charge to use up the foundry returns of nickel cast iron.

A very dense cast iron with small graphite flakes is thus obtained which has a tensile strength of 22 to 26 tons, mainly depending on the total carbon content, and this strength can be improved by suitable heat-treatment. The great advantage of the processes involving inoculation is the certainty with which one can obtain tensile strengths of 23 tons and over. Processes in which the total alloy additions are made to the cupola charge require much greater care and attention. As in all high-duty irons, silicon may vary between wide limits without much effect on the tensile strength, but it is advisable to keep the manganese content above 0.8 per cent. in view of the inevitable sulphur pick-up.

In casting, good heads are essential in view of the shrinkage, and almost invariably the moulds must be thoroughly dried; in some instances, however, this is not essential.

The production of high-duty iron demands good cupola practice, and any well-designed cupola which is worked with due care will yield satisfactory results. Owing to the large quantity of steel scrap in the charge, the air-blast must be very carefully adjusted; excessive oxidation will occur if the blast is too great, and will give rise to a black frothy slag.

Shifting of the constituents of a charge is a common fault; for example, ordinary so-called fist-sized pieces of ferro-silicon are very apt to trickle down from a higher to a lower charge, and lumps of ordinary ferro-chrome seem to find their way into any charge and invariably leave a trail through succeeding charges. It therefore follows that care should be taken in the selection of the components of the charge, particularly in regard to size and relative melting points. In adding the components of the charges to the cupola, it is customary to add the steel scrap first, followed by the pig-iron and remelts together with the alloy additions. Recently it was suggested to the author that the steel scrap should be added last, but, though this procedure has been tried several times, no material improvement in the resultant iron has been noticed by this inversion of the customary order. No doubt the order of charging is comparatively immaterial where the bulk of the mix consists of steel scrap.

In conclusion, the author would like to emphasise that, in the production of any high-tensile cast iron, as much, if not more, consideration should be given to the materials, *i.e.*, the iron, the steel scrap and alloying elements, as well as to the chemical composition of the final cast iron. In other words, one must choose irons which have good "inherent properties" even for melting down and preparing a synthetic white or grey base iron. The use of de-oxidising agents in the preparation of high-duty cast iron is also to be greatly insisted upon. In most cases the addition of a good de-oxidiser makes at least 10 per cent. difference to the strength of the iron.

DISCUSSION

MR. G. HALL said that, as a practical foundryman, he greatly appreciated the way the lecturer had dealt with the subject. Mr. Williams had spoken about the importance of high tensile strength, and in every Paper to-day on high-duty cast iron this high strength was always stressed. He agreed with Mr. Williams that iron of 18 to 20 tons tensile strength was very nice to make and rather appealed to most foundrymen; iron of 22 to 24 tons was quite another proposition and involved considerable alterations in normal foundry working.

Lanz-Perlit iron was produced in an ordinary foundry with just a few additions and perhaps more care in controlling the cupola, but not necessarily with a quantity of instruments. He had seen cupolas worked for Lanz iron without any instruments except a water gauge. They had never made a point of getting over 20 tons as there was no object in doing so; irons of 14, 16 and 18 tons were quite easily obtained from the cupola without any additions whatsoever. To-day one had to add nickel, chromium and other alloying elements to produce high-duty cast iron, which was very costly. The speaker did not consider high tensile strength to be so important as the production of good wearing and good heat-resisting cast irons.

Cupola Control Essential

MR. WILLIAMS, replying, said he hoped that in referring to the Lanz and other processes he had not given the impression that they required an excessive amount of cupola control with the use of elaborate instruments. It was necessary, however, in all processes for making high-tensile iron to exercise a certain amount of control to ensure that the furnace was neither under- nor over-blown, and for that purpose a blast volume meter was very useful.

With regard to the Lanz-Perlit, it was a very good process for producing heat-resisting cast iron, and was made by some firms without any instrumental control of the cupola. It was easy to get 20 tons tensile by the process, but not so easy to exceed that figure. The other methods outlined in the lecture rendered the production of high-tensile iron over 22 tons more certain. In ranging over a wide field, he had mentioned a method of making high-duty iron without any of the usual alloy additions, such as nickel, chomium and molybdenum. The use of nickel and nickel-chromium simplified the process and eliminated any uncertainty. The cost had to be considered, but if it enabled one to get away with the job, this was of secondary importance.

Simplification Desired

MR. J. L. FRANCIS agreed with Mr. Hall that complications and special tackle in the foundry were to be avoided as far as possible, but he thought it a big point with these high-duty irons that special equipment was unnecessary. There was no point in securing high strength unnecessarily, but some of the newer types of alloy iron did widen the field for ironfoundry products, and thus help in the securing of business which had been slipping away gradually to the steel founder, the fabrication people, and even to the non-ferrous founder. Apart from the actual increase in strength, the introduction of alloys into cast iron had produced material with new properties, and in this respect the cost of the alloy additions was justified.

The Lanz process was a pioneer process, and at the time it was introduced was a very big step forward. A maximum of 20 tons tensile was about the limit for this particular process, chiefly because the abnormally slow cooling which was necessary to produce machinable castings occasioned rather coarser structure of the graphite flakes.

Incidentally, the whole of the range of processes which had been introduced at any time for the production of high-tensile iron had, in some shape or form, taken steps to control the carbon in the iron, especially graphite, as it was the graphite which lowered the strength.

Another point in connection with alloy additions to cast iron was that they gave a much more uniform structure throughout different sectional thicknesses, and where one had to make castings to withstand internal pressure, this was a great advantage. Castings made without the alloy might show leakage of water and were scrapped. In this case the cost of the casting and its machining was lost. Often a few shillings spent on alloy additions would prevent such loss of time and money.

Manganese-Sulphur Ratio

Concerning manganese, it occurred to him that Mr. Williams had not mentioned that the manganese-sulphur balance had been definitely stated by Norbury as 1.72 times the manganese plus 0.3 per cent., which was a safe minimum ratio. As to the addition of the alloys, he personally, wherever possible, preferred to make additions to the ladle, probably because his experience lay in that direction. One might have to add it to the charge where the conditions called for high percentages.

Nickel was an advantageous alloy to use; it gave a good range of properties and it was "fool-proof," because it did not adversely affect other irons which one did not want alloyed, whereas chromium was a powerful hardening element and might give rise to trouble if it found its way into material where it was not required. Molybdenum additions were not more expensive than nickel, because molybdenum was more active, and one part of molybdenum was equivalent to three parts of nickel, so that for equivalent additions the cost worked out about the same.

In introducing alloys, the charge should always be adjusted so far as silicon content was concerned. Another method for the production of high-duty iron was the duplex, utilising one cupola melting white iron and one melting grey iron, and by mixing the two molten metals in various proportions one could obtain a range of irons which had different properties from those obtained by melting white and grey iron together.

MR. WILLIAMS was pleased to hear what Mr. Francis had said about the relative cost of molybdenum. He quite agreed that the foundry people had a good opportunity to recover some of the business which had been taken from them by the steel founders. He was not quite so sure about the sulphur-manganese balance propounded by Norbury. Theoretically, this ratio of manganese to sulphur should be quite satisfactory, but much depended on the form in which the manganese was added and the rate of melting. Numerous cases were on record where the iron/iron-sulphide eutectic had separated in the presence of a large excess of manganese; McNair* had mentioned a case where this eutectic had segregated out from 0.07 per cent. sulphur in the presence of 0.82 per cent. manganese.

MR. H. H. SHEPHERD, proposing a vote of thanks to the lecturer, said foundrymen seemed to have advanced a very considerable way in foundry practice, and also in metallurgical practice, but he noticed the use of the term "semi-steel" persisted. He suggested its elimination and substitution by the phrase "ferro-steel." The making of malleable iron from an all-steel mix was undesirable from the practical point of view, and experimenters should be discouraged.

Tensile Strength

On the question of tensile strength, he felt that, despite all the advance registered in connection with the physical properties, people still judged cast iron by its tensile strength. It was possible to produce very high-tensile irons, but they were useless. Tensile strength in itself was not a criterion of the iron. If there had been sufficient attention given to phosphorus in the past there would have been considerable room for a cheap and good tensile iron.

He had stated repeatedly that he believed the inoculated type of iron would be the iron of the future, and he had also expressed the opinion that with a white-iron base and a proper system of inoculation one could produce almost any type of casting.

Some of the aluminium-molybdenum irons had very good properties. These alloys appeared to be very expensive, but when one took into account the use they could be put to, the expense was quite justified. He then proposed a vote of thanks to Mr. Williams.

* FOUNDRY TRADE JOURNAL, March 1, 1934.

Influence of Phosphorus

MR. WILLIAMS said he had no pretension to being an expert on malleable iron, but had referred to the matter because it seemed to be the practice in Sweden, where they had to melt white iron to adopt the practice of using steel with additions. Possibly one of the reasons they had trouble was because they tried to melt too fast. He agreed with Mr. Shepherd with regard to the transverse test of iron, and that frequently this was of much greater importance than mere tensile strength. On the question of phosphorus, he disagreed with Mr. Shepherd; no doubt the idea of a low phosphorus content might be overdone, yet in many cases a phosphorus content of 0.8 per cent. was a useful ingredient so far as wear was concerned. On the other hand, it did lower the transverse test and, in pressure-tight castings, was very apt to lead to porosity. In high-tensile cast iron, where one was aiming at strength, a low phosphorus content was essential. With regard to molybdenum, he did not stress its use, because he did not think it was required for producing a high-tensile cast iron, but it was useful for giving a high impact test.

Meeting Competition

MR. T. R. REAVELL (Norwich), who seconded the vote of thanks to Mr. Williams, complimented the author on his ability to explain metallurgical matters so lucidly. Information of this nature was usually given in such a way that it was not easily understood. The iron foundry industry was feeling the competition of the steel founder, and, in the case of his firm, it was losing orders for certain types of work where they called for steel. It had to adopt new measures, and by alloy additions it was now able to produce iron with over 22 tons tensile, and as a result the firm had recovered quite a lot of business and, moreover, had received orders for castings that were originally made in steel.

MR. WILLIAMS thanked his audience for the generous reception accorded to his Paper.

(*Continued from next column.*)

Units of the type described are not only available for the additions of individual elements but also for complex compositions of any type. If, for instance, a foundry wishes to alloy its iron simultaneously with nickel, chrome, and molybdenum in a certain predetermined proportion, one single compound is available which will give a yield of all of these three elements in the required proportion. Also silicon, manganese, and phosphorus can be added to the iron in the ladle in this manner, and the advantages which are assured by this possibility enables the foundryman to determine the composition of his iron in each ladle separately, according to specification or requirement.

It has been demonstrated by means of extensive tests that alloying elements up to an extent of 6 per cent. can be added to the ladle without difficulty by the use of this method, and that the casting properties and other qualities of the iron can even be considerably improved by these high additions.

Combined with this new process, there is also a new desulphurising effect which introduces no slag difficulties, and is free from fumes and smoke. The material in question has also been so compounded that a chilling or cooling of the iron is avoided under all circumstances, and furthermore it forms a slag which can be removed without the slightest difficulty. Above all, the material embodies the advantage of transforming the sulphur which remains in the iron into manganese sulphide, so that the important disadvantages which otherwise would result because of the sulphur content are completely eliminated.

Ladle Additions to Cast Iron

A MODERN PROCESS

The progress during the last few years in the production of high-grade cast iron, stimulated by the necessity of adapting itself to the increasing demands of engineers and designers, presents the foundryman to-day with the frequently difficult task of having to produce a cast iron of predetermined composition within very fine limits of accuracy. This task becomes even more difficult if he has to alloy the iron with elements such as nickel, chromium, molybdenum, and the like.

The obvious method, that of blending the furnace charge in such a way that the iron at the spout will be of the required composition, is not always practicable. The elements generally accompanying the iron, as well as the alloying elements, are frequently subject to changes in the cupola due to oxidation, slagging, etc., and variations in the composition and metal losses must therefore be taken into consideration. In addition, it must be realised that, in the case of furnace additions, the whole of the furnace charge will be of one and the same composition, whereas it may often occur, for reasons of economy, that only a small proportion of a charge is to be alloyed, especially if the more expensive elements are to be used. Even if, in this latter event, the required components are added in the ladle or the spout, it is extremely difficult to avoid inaccurate results.

The reason for this lies in the fact that there are no iron-accompanying elements and alloys available in a form suitable for ladle addition, and any processes so developed still possess considerable and vital disadvantages which easily nullify their usefulness. The foremost of these disadvantages lies in the cooling or chilling of the iron due to the heat absorption of such additions, combined with technical difficulties as regards alloying and casting arising from these conditions. In order to overcome these difficulties, a process—designated "Addalloy"—has been developed, which after extensive tests can be considered as a really satisfactory solution of the problem and signifies an important step in the development of the production of high-duty cast iron.

Exothermic Alloy Additions

The process departs from the standard practice inasmuch as the alloying elements such as nickel, chrome, molybdenum, copper, titanium, tungsten and vanadium are not added to the ladle in the form of their ferro-alloys, but of a special patented composition, having such qualities that a rapid exothermic reaction is created, causing the various alloys to melt immediately and disseminate themselves in the iron without any marked decrease in temperature. By this method, even a slight temperature increase is produced, and this, combined with the turbulence created during the solution of the alloying elements, leads to a homogeneous distribution which is essential for the achievement of perfect results.

Further advantages of the use of these compounds are that at the same time they have a desulphurising and general cleansing effect on the iron. In addition, each compound is so composed that, on adding it to the ladle it gives a definite predetermined yield of the required element, corresponding to the amount added, and completely mixes with the iron, thereby assuring accurate results and avoiding losses of metal. A weighing of the ingredients is, therefore, unnecessary, as the amount added can be determined simply by counting the number of units—an operation which any normally intelligent workman can carry out without the possibility of errors occurring.

(*Continued in previous column.*)

Production of Castings from Shell Patterns*

By JOHN CAMERON, Junior

It is only proper, for anyone setting out to present a Paper such as this, to define the scope of his remarks, even if it is only to prevent him from straying too far from the immediate subject of the production of castings from shell patterns to the larger subject of the production of castings in general. Thus, by "shell patterns" is meant any patterns which leave their own cores, or, alternatively, a pattern which does not incorporate the use of cores made from a separate corebox.

For the actual production of castings, exactly the same plant is required as for other types of moulding, namely, sand, a moulding box and a pattern whose outer surface is a facsimile of the object to be produced, and whose inner surface forms the shape of the core. In a centre such as Falkirk, which is very closely associated with the pipe trade, the majority of soil and rainwater pipe connections will all be made from shell patterns, and it will be realised that the skill of the individual moulder is the deciding factor where the moulding principle is so well-known.

FIG. 1.—INTERCEPTOR TRAPS MADE WITH SHELL PATTERNS.

FIG. 2.—THE SAME PRINCIPLE APPLIED TO ANTI-FLOODING BALL VALVES.

FIG. 3.—A 6-IN. INSPECTION-PIPE SHELL PATTERN.

FIG. 4.—INSPECTION PIPE MOULDS READY FOR CLOSING.

Sand

Sand is a material which up to a few years ago was taken almost entirely for granted. If a certain fault started in the casting, such as scabbing, a certain empirical remedy was applied, and by a system of trial and error the trouble was eventually removed. Now, however, we are in a much more happy position regarding the sand. A regular series of tests typified by Table I has been developed. These can be simply and effectively used in any foundry, and cover green strength, dry strength, permeability, grain size and moisture, and it is known that if the sand gives certain figures on these tests, then good clean castings, free from scabs, blowholes and misruns, can be reasonably expected. Personal experience shows that a sand conforming to Table I gives very good results for the average run of castings produced at the author's foundry. The permeability figure is probably higher than that generally found in the Falkirk district, due to the higher average weight of the castings therein produced, and this figure is reflected in the grain-size distribution of the floor sand. The raw sands used are Avenuehead rock sand, Erith loam, and a synthetic sand formed from burnt core sand, bonded with Colbond. The new core sand is a wind-blown sea sand from Irvine, and, provided that reasonable care is exercised to maintain the fines at a certain figure, this sand gives very good results.

Moulding Boxes

The question of moulding boxes for this type of work is very difficult, as a system has arisen in the trade of having a box for each separate pattern. Where there is little chance of a change in design of the casting, this system has undoubted advantages, as bars may be specially shaped, and everything formed just to fit the pattern and no more, but, unfortunately, almost everything changes sooner or later and the boxes have to be scrapped. A personal prejudice is in favour of using simple forms of moulding boxes, carefully thought out as regards length, width and depth, which will cover the entire range of regular lines of castings, and at the same time allow a suitable box to be selected to make that inevitable special, which always just fails to fit a box designed solely for a particular line of castings.

The result of a system of a box per pattern can be seen in almost every foundry producing light castings, where the box yard generally

* A Paper read before the Falkirk Section of the Institute of British Foundrymen.

exceeds the moulding shop in area, and is filled with piles of scrap iron which would be far better in the furnace than slowly rusting away waiting for the day when they may be called on to make half a dozen castings, then sent out to the yard again.

Shell patterns, owing to the fact that they make or leave their own core, pre-suppose hand moulding, and not only hand moulding but skilled moulding. For this reason the standard of accuracy demanded of a machine pattern is not so essential, and frequently the skilled moulder produces a perfectly shaped casting from what would look to the outsider to be a pile of scrap. This remark does not refer to the castings which it is now proposed to illustrate and describe; they consist mainly of special drain castings which have been supplied in the ordinary course of trade during recent years.

Special Drain Castings

Fig. 1 shows a 6-in. interceptor trap with a 6-in. back inlet and a 4-in. reverse clearing arm. This casting is in regular production, and therefore is made from a whole pattern; this pattern can clearly be seen between the two halves of the box, while in the foreground lies the finished core, the whole mould being ready for closing. Fig. 2 illustrates the same features, but this time the subject is a 4-in. anti-flooding ball valve. Again, a whole pattern is used, but here, owing to the shape of the casting, balancing arms have to be employed to keep the heel of the core from moving during casting. Reference to the design of core bars will be made later on.

Temporary Patterns

From these two examples of castings produced from permanent shell patterns, the subject passes to examples of types produced from temporary or "pieces" patterns. After seeing a few examples of this type, no one will have any difficulty in understanding the meaning of a "pieces" pattern, and Fig. 3 shows the pieces pattern for a 6-in. inspection pipe. The various pieces are held in position on the board by a few nails, and this whole pattern probably only took an hour to assemble and fit together. The moulding processes are clearly seen in Fig. 4, which shows the mould ready for closing. Three-part boxes are used for these "one-off" castings; they are usually poured through runners at each end, and use is made of the ubiquitous cotton thread, without which no connection-moulder seems to be happy.

Fig. 5 shows the making of the top half of the core of a 4-in. flanged bend, 8 ft. 6 in. long. These castings are tested usually to 100 lbs. per sq. in., but frequently at much higher pressure, so that it is essential to have the core mathematically concentric with the body. This can be done either by the use of a considerable number of studs or chaplets, thus increasing the risk of leakage in the finished casting, or by eliminating chaplets altogether, using one stud, and designing the corebar to give the maximum rigidity combined with strength.

Cast-Iron Corebars

It is surprising how few moulders realise the valuable physical properties of cast iron, particularly its rigidity, when they are making corebars or grids. A corebar should always be made as deep and as narrow as possible for the centre or main part, and use made of short lateral webs with toes on them for holding the sand both on the top and bottom halves of the core. Such a core iron is a rigid structure and resists bending in a vertical plane. This directly affects the number and strength of the studs required to hold the bar down, and also directly influences the chances of a good casting. A heavy, shallow half-round bar is only a nuisance in a foundry, has a very small degree of rigidity, and frequently weighs twice as much as a bar in which a little care and knowledge of the properties of cast iron have been used during manufacture.

This question of the weight of corebars is especially important to-day, when every founder must keep cost down to a minimum. The reaction, "I can't risk a casting for the sake of saving a few pounds weight in the core iron," is unwarranted. It is suggested, however, that thought be given as to how by skill the strength of the core iron can be increased by a reduction in its weight. In the author's foundry, the yield of castings has slowly increased from 62 to 68 per cent. at present, in spite of a reduction in heavy pipes cast, and it is certain that an appreciable part of this increase is due to the realisation by the moulders of the fact that a heavy corebar is not necessarily a rigid bar.

Fig. 6 illustrates three flanged headers, part

FIG. 5.—TOP HALF OF A 4-IN. FLANGED BEND 8 FT. 6 IN. LONG.

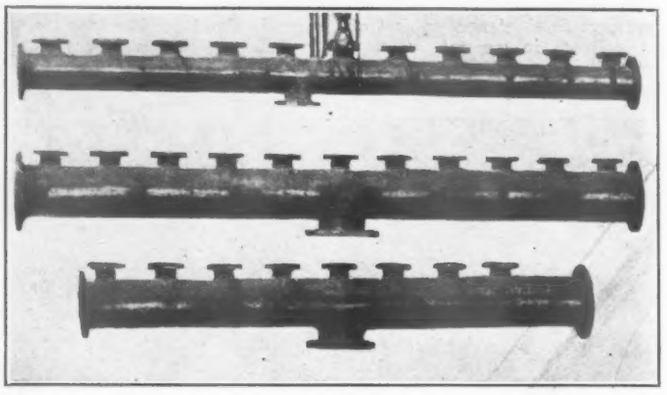


FIG. 6.—THREE FLANGED HEADERS MADE BY USING RIGID CAST-IRON COREBARS.

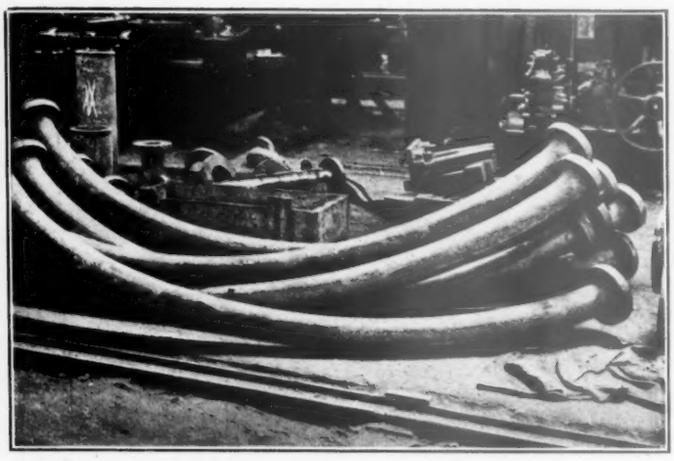


FIG. 7.—LONG FLANGED BENDS MADE IN MEEHANITE METAL.

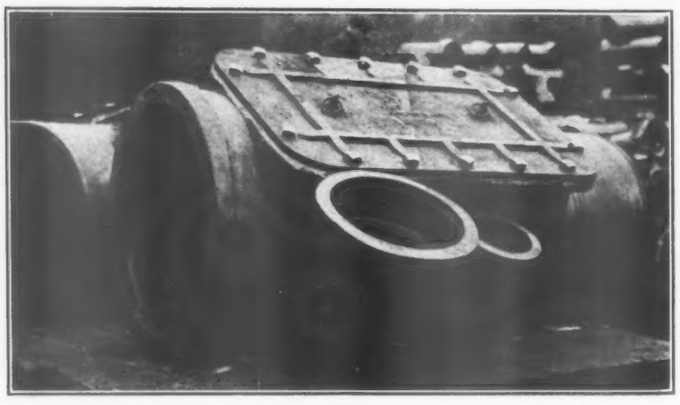


FIG. 8.—AN 18-IN. VERTICAL INSPECTION PIPE FOR EARLS COURT EXHIBITION DRAINAGE SYSTEM.

of an order for an oil refinery. The top casting is 8 in. bore by 13 ft. 6 in. long, and has eleven 4-in. flanged branches on one side; the centre casting is 12 in. bore by 13 ft. 6 in., and the bottom casting 12 in. bore by 10 ft. 6 in. long. All these castings were made in green sand, metal ¾ in. thick, rigid corebars were employed and

FIG. 9.—AN 18-IN. INTERCEPTOR TRAP FOR EARLS COURT.

there were no defective castings. The test pressure was 150 lbs. per sq. in., and "pieces" shell patterns were used. All the branches were moulded on the parting, and particular care was taken to relieve the sand at the back of each end flange after casting. The normal contraction on these long castings is 1⅛ in., and if this

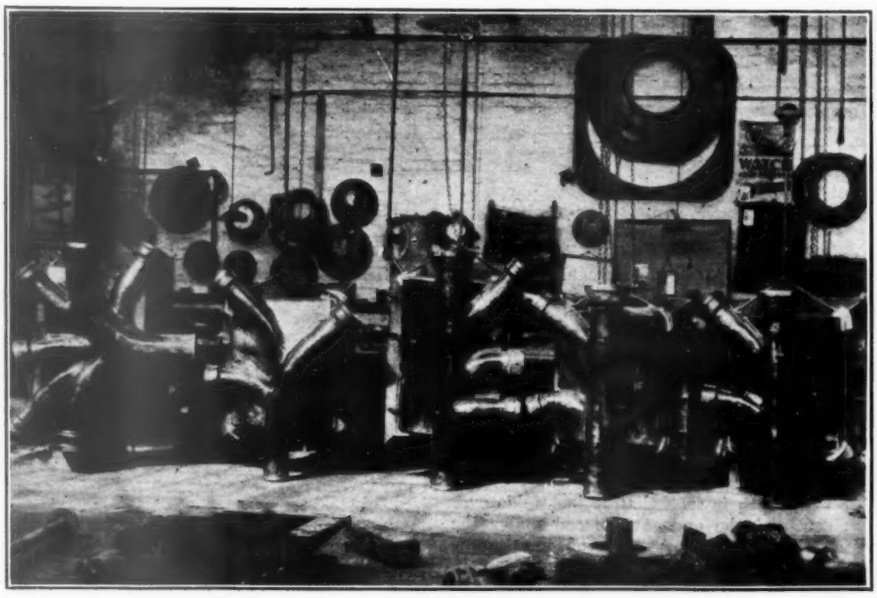


FIG. 11.—SPECIAL MANHOLE BOTTOMS FOR THE BANK OF ENGLAND.

precaution be not taken, one can expect to find one end flange torn off on opening the box next morning.

It is now proposed to deal with a small flanged connection, which, in addition to having a side branch, has a few bosses and hinge lugs top and bottom. With thoroughly skilled pattern-making there is no limit to features of a special nature which can be added to a "pieces" pattern of this type with the greatest of ease.

Long Flanged Bends

The successful production of long flanged bends such as are shown in Fig. 7 calls for the very highest degree of skill from the moulder. These particular castings are complicated by the fact that they are cast in a high grade of Meehanite metal with a strength of over 21 tons per sq. in., and a phosphorus content under 0.1 per cent. They are subject to working conditions calling for complete absence of leakage at a pressure of 350 lbs. per sq. in. at a temperature of 300 deg. C. Naturally, chaplets or nails have to be reduced to a minimum; in this case only one was used in each casting. The corebar has to be as rigid as possible; this is helped in these castings as they are 5 ft. radius from flange to flange, so the bar comes out without having to be broken. It is also very important to fill these moulds steadily and evenly, and with this end in view eight ingates were provided on

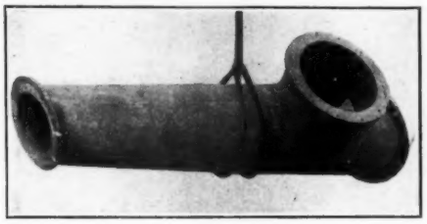


FIG. 10.—A 30-CWT. GREEN-SAND CASTING MADE FROM SHELL PATTERN.

the parting; these ingates are fed by two down-gates, and care is taken to throttle the metal flow before it enters the mould to avoid high velocities and the risk of sand washes. It must always be remembered in the production of castings, particularly in green sand, that all the iron has to flow down the gate before it enters the mould; consider then, the care with which we finish the mould, often in places where only a few pounds of molten iron may flow, compared with the scant attention often given to the gates which are the medium of conveying several hundredweights of metal from ladle to mould.

Figs. 8 and 9 illustrate two large 18-in. castings supplied for the main-drainage system at the Earls Court Exhibition building in London. Fig. 8 is an 18-in. inspection pipe with a 9-in. and a 6-in. vertical socket branch on the left-hand side. This casting was moulded in green sand and from a "pieces" pattern in a three-part moulding box. The moulding was com-

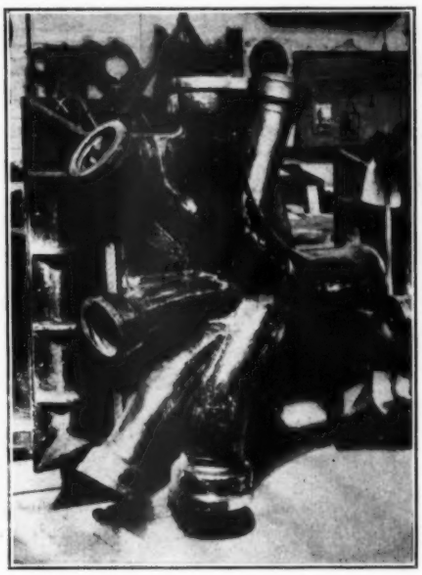


FIG. 12.—CLOSE-UP OF THE LEFT-HAND CASTING IN FIG. 11.

plicated by the fact that the sockets of the vertical branches had to be in exact positions relative to the main bore of the chamber, and the patternmaker thus could not just finish them off flush with the flange round the opening; also the sockets had to be correct to British Standard sizes internally and externally. Block cores were used to take out the internal groove on the vertical sockets.

Fig. 9 shows an 18-in. intercepting trap with a 9-in. clearing arm. This casting is nothing like so complex as the previous inspection pipe, but both castings are out of the ordinary as

TABLE I.—*Properties of Pipe-Connection Heap Sands.*

Moisture	Per cent.	9.4	8.5
Apparent density		1.6	1.57
Green strength ..	Lbs./sq. in.	3.6	4.0
Green permeability		39	38
Dry strength ..	Lbs./sq. in.	17.5	25
Dry permeability		78	—
Loss on ignition ..	Per cent.	5.5	6.1
Clay	„	5.0	4.0
SIEVE TEST.		Per cent.	Per cent.
Left on 30		4	6
„ 40		4	4
„ 60		6	6
„ 90		36	38
„ 120		20	20
„ 200		14	12
Through 200		16	14
		100	100

regards size, and for this reason alone very special care was taken during their manufacture.

Fig. 10 shows what is perhaps one of the largest green-sand pipe castings the author's foundry has produced. It was for a local colliery company and weighed around 30 cwts. The main bore tapers from 24 to 18 in., with a 24-in. branch, and all flanges were to template. It is quite a nice little casting to have produced from a "pieces" shell pattern.

Bank of England Manhole Bottoms

The next few illustrations relate to the moulding of a number of special manhole bottoms

which were cast in connection with the rebuilding of the Bank of England head office. Fig. 11 shows the inside shape of five of these castings after the top flanges have been machined and the shaped waterways at the bottom of each can just be discerned. The size of these manhole bottoms varied from about 3 ft. 6 in. square by 2 ft. deep to 24 in. by 18 in. by 6 in. deep. With each bottom were cast several eke pieces having simple sockets cast on at definite points to catch drains coming in at higher levels. Some complete units were over 30 ft. deep. Usually the main outlet spigot was 6 in. dia. with several 4-in. branches, but in the smaller units 4 in. dia. was used throughout. The left-hand casting is shown in detail in Fig. 12, and it will at once be observed that only two of the sockets are on the same level. The invert of each 4-in. socket is different, only small on two of them but quite considerable on the others. This casting is quite shallow, but some were much deeper, and the top flange and the flanges of the various ekes had to be machined to bring the sockets accurately to predetermined positions so that the setting of a core in such a casting as this was a most particular and exacting piece of work.

Fig. 13 shows the core just prior to its being put back into the box. The varying levels of the core branches can easily be seen. The core-iron was made by inverting the pattern board on a level sand bed, and establishing the various levels of each branch. These branches were then levelled off and the shape of the bar fingered out inside the pattern impression. Where levels varied, such as in this casting, the lower arms were covered over with strips of paper, and sand heaped on top to resist the fluid pressure while casting the core iron.

FIG. 13.—CORE FOR JOB ILLUSTRATED IN FIG. 12.

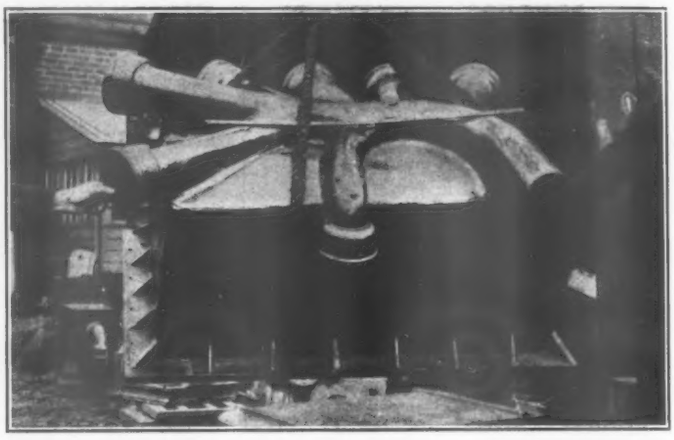


FIG. 14.—DEEPER CASTING THAN THAT IN FIG. 12, CARRYING A VERTICAL SOCKET.

Fig. 14 shows another rather deeper casting, with a vertical socket to help to worry the moulder. It will be observed that the varying inverts of the sockets are again present. Exactly the same moulding procedure was followed with this type of vertical socket as with the 18-in. inspection pipe, and a separate block core used to form the groove inside the socket. In Fig. 15 is shown the box ready for the top part being closed on; the core is very clearly shown, but, unfortunately, from the side opposite to the vertical branch. Wooden ekes, such as shown, are often used to give the right depth of the mid-part, but very great care must be exercised when putting on the top part to avoid "off the twist" castings, or, worse still, a crush. No bars can be used in the mid-part when moulding such a casting; instead, in order to hold the sand firmly in place, several holes are drilled on each side and short bars of iron jammed in. The projecting ends of several of these bars are shown in the photograph. Beyond the mid-part can be seen some of the pattern. This illustrates the general construction employed, the main part being built up of wood, with the bottom flange fixed on, and loose iron pieces placed on to form the top part.

FIG. 15.—MOULD READY FOR CLOSING.

Patternshop Expedients

BY H. R. THOMAS.

Not every patternshop is equipped with modern woodworking machines such as bobbin and disc sanders, and other means have to be adopted to finish patterns and core-boxes. There are a number of jobs where even the sanding equipment, if installed, is not necessarily suitable and methods as used in the smaller shops must be applied. Fig. 1 illustrates a portion of a core-box, the diameter of which is required

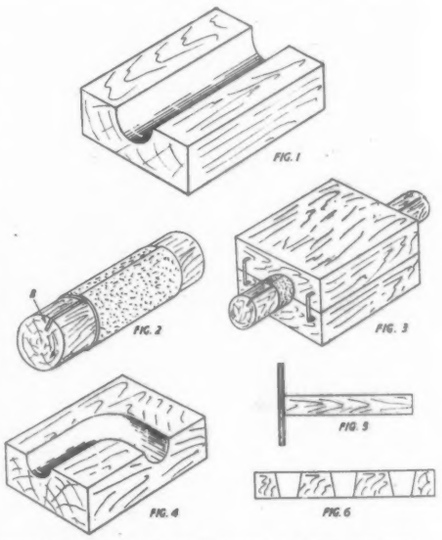
(*Continued from next column.*)

than their diameter. For smaller boxes in which the diameter is almost equal to the length a turned block can be wrapped with sandpaper and held in a vice while the core-box is worked down over it.

Another type of core-box which is somewhat difficult to sandpaper is that for a pipe bend (Fig. 4). After the most careful gouging there are still a number of irregularities to remove with sandpaper, and unless some type of sandpaper block is used the workman's fingers invariably get rubbed. For the straight portion a piece of shaped cork would be ideal, but this would not suit the double curve in the curved part. Fig. 5 shows a useful rubber for such a case. It consists of a piece of flexible material about ¼ in. thick, such as sheet rubber, and approximately 2 or 3 in. square. This is screwed to a wooden handle and so arranged that when a piece of sandpaper is cut to the width of the rubber the length is such that it just folds over the rubber and the ends are placed under the neck of the handle. A turn of the handle tightens the screw and holds the sandpaper in place, and the device is ready for use.

Often small taper cores are required and a multiple core-box, as Fig. 6, is supplied. These boxes are somewhat difficult to finish smoothly, as the taper and smallness of the hole do not allow of the use of a rubber covered with sandpaper. An iron bar turned the size and shape of the hole, but longer for holding, is heated and then placed in each hole, and a smooth surface is formed by the irregularities being charred.

"dead true." After the preliminary gouging of this box, it can be finished by the use of a device shown in Fig. 2. This consists of a piece of timber turned to a diameter less than that of the required core and longer. This is then marked for replacement in the lathe and removed. A saw cut is made along the length and partway through the diameter as B. A



standard sheet of sandpaper is then inserted in the groove and wrapped around the roller. This is then returned to the lathe and the two halves of the core-box placed over it and clamped together as shown in Fig. 3. Care must be taken that the sandpaper is wrapped in such a manner that when the roller revolves the sandpaper is not torn off, but the joint is opposite to the direction of rotation, as Fig. 2.

This simple expedient will be found very useful for round core-boxes whose lengths are greater

(*Continued in previous column*

Of interest to Pig Iron Users

THE STANTON METALLURGICAL SERVICE

The Stanton Company believe that a mutual policy of collaboration in more scientific and better methods of manufacture, can do much to widen the field for cast-iron products.

The Stanton Company therefore offer to all those engaged in the Iron Foundry Trades the free advisory service of specialists in metallurgical practice and technique.

This service takes the form of analyses and tests by the Company's Research Department on castings submitted to them, and constructive suggestions if the desired results are not being attained.

Where there are difficulties in works practice which can best be investigated on the spot, the service provides for a personal visit from a Stanton metallurgical expert, who will collaborate with the foundry staff.

THE STANTON IRONWORKS COMPANY LIMITED
Near NOTTINGHAM

The Largest Producers of Foundry Pig Iron (for Sale) in Great Britain

The Week's News in Brief

Trade Talk

THE WORKS of Henry Balfour & Company, Limited, Durie Foundry, Leven, may be extended to cope with a manufacturing programme for the Air Ministry.

THE PRINCIPAL GUEST at the annual dinner of the Institute of Metals, which will be held at Grosvenor House, London, on March 8, will be the Air Minister, Sir Kingsley Wood.

THE SOUTHERN RAILWAY have placed an order with Wm. Denny & Bros., Limited, Dumbarton, for a cross-Channel vessel for the Calais-Dover and Folkestone-Boulogne services. It will be turbine-driven, steam being supplied by coal-fired Yarrow boilers.

THE INTERNATIONAL MEEHANITE METAL COMPANY, LIMITED, has licensed C. A. Parsons & Company, Limited, of Newcastle-upon-Tyne, to manufacture Meehanite metal. This company, which is the largest manufacturer of industrial turbines in the world, is to use Meehanite metal for the production of their various castings.

WHEN A CASTING was being poured at the works of Robey & Company, Limited, Lincoln, last Thursday, there was an explosion which shot molten metal up to the roof, which was set on fire. The city fire brigade was called upon to extinguish the outbreak. Three men—two crane operators and a moulder—had to be treated for burns.

THE GENERAL COMMITTEE of Lloyd's Register of Shipping offer a scholarship, valued at £100 per annum and tenable for three years, to be awarded on the results of the Studentship Examination of the Institute of Marine Engineers in May next. The scholarship is intended to assist marine-engineering students to take an advanced course of instruction in engineering subjects. The age limit is 18 to 23 years, and the closing date for entries is April 8, 1939. Full particulars, entrance forms, and copies of previous Papers may be obtained on application to the Secretary of the Institute of Marine Engineers, 85, The Minories, London, E.C.3.

EIGHT manufacturers in the Barton & Sons (1935), Limited, group have formed a special company to co-ordinate and develop their overseas trade. Paclantic Exports, Limited, is the name of the concern, and the eight participating companies are: Barton Conduits, Limited, Walsall; the Bolt & Nut Company (Tipton), Limited, Tipton; Clydesdale Stamping Company, Limited, Netherton; John Fellows & Company, Limited, Bilston; Harrison Bros. (England), Limited, Middlesbrough; Neon Manufacturers, Limited, Birmingham; Premier Aluminium Casting Company, Limited, Birmingham; and Wright Anderson & Company, Limited, Gateshead-on-Tyne. The capital of Paclantic Exports, Limited, is £5,000.

E. K. COLE, LIMITED, radio manufacturers, of Southend-on-Sea, inform us that they are willing to place at the free disposal of responsible executives in the foundry industry the experience that concern has gained in the construction of air-raid shelters to accommodate 3,000 employees. These shelters are timber-lined throughout, equipped with electric light, emergency generator, telephones, radio, first-aid bays, drainage sumps, etc., and have been highly commended by A.R.P. experts. The firm evolved its own system of construction, which proved very satisfactory in cost, speed of completion, and in producing galleries of regular shape and section. The whole staff, although they have to be gathered from the limits of a factory area of 300,000 sq. ft., can be safely underground within 6 mins. of an alarm.

Company Reports

Range Boilers, Limited.—Net profit for 1938, after tax, £17,456; brought in, £1,877; final dividend of 10 per cent. and a bonus of 5 per cent. on the ordinary shares, making 20 per cent. for the year; to general reserve, £4,000; carried forward, £2,573.

Waygood-Otis, Limited.—Net profit for 1938, £146,776; brought in, £13,279; to pensions reserve, £10,000; final dividend of 12½ per cent. and a special bonus dividend of 20 per cent. on the ordinary shares, making 45 per cent. for the year; carried forward, £10,555.

Personal

MR. ROBERT C. STANLEY, chairman and president of the International Nickel Company of Canada, Limited, has been nominated as a director of the United States Steel Corporation, to succeed Mr. Walter S. Gifford.

Wills

KENT, SIR WALTER G., chairman and managing director of George Kent, Limited, Luton	£54,324
ALLINSON, G. H., of Helensburgh, divisional area manager for W. & T. Avery, Limited, of Birmingham ...	£11,295

Obituary

MR. E. C. RANSOME, chairman of Ransomes, Sims & Jefferies, Limited, died at Ipswich on February 15 at the age of 74. He was the eldest son of Mr. James Edward Ransome, who died in 1905. In 1886 he entered the workshops of the Orwell works, a business which had been founded by his great-grandfather in Ipswich in 1789. Two years later he became manager of the foundry, and in 1890 was given charge of the firm's cost and wages departments. On the death of his father he was elected a managing director of the company, retaining this position until 1919, when he was appointed chairman of directors.

WE REGRET to announce the death of Prof. Jerzy Buzek, managing director of the Wegierska Gorka Ironworks Company, and one of the most distinguished figures in the foundry industry in Poland. In addition to his industrial activities, Prof. Buzek occupied a chair at the Mining and Metallurgical College of Cracow. He was a founder and Past-President of the Polish Foundrymen's Association, and took an active part in last year's International Foundry Congress in Poland. He delivered the closing lecture at that Congress, and the British delegation will remember particularly the hospitality which he tendered to the delegates on the occasion of their visit to the works which he controlled at Wegierska Gorka.

Company Meeting

International Combustion, Limited

The annual meeting of International Combustion, Limited, was held in London on February 9. MR. G. R. T. TAYLOR (chairman) said that the results of the past 12 months' working had been achieved without altering their usual low ratio of profit to gross turnover and had been made possible by a still further large increase in the output of the company, which was necessary in order to enable them to fulfil their obligations to customers at home and abroad. They found it necessary to make some extensions to their works at Derby. They had to extend the main machine shop, and extensions and improvements had also been made in their foundries, pattern shops, pattern stores, and plate shops, and in the large area devoted to fabricated steel products.

Contracts Open

Luton, February 28.—Cast-iron, drawn steel or concrete columns for street lighting, for the Borough Council. Mr. J. W. Tomlinson, borough engineer, Town Hall, Luton. (Fee £2 2s., returnable.)

Shipley, March 1.—Cast-iron pipes, cast-iron specials, and steel reinforcement, for 12 months commencing on April 1, for the Urban District Council. Mr. H. Dawson, surveyor, Town Hall, Shipley, Yorkshire.

Shrewsbury, February 27.—Iron castings for the year ending March 31, 1940, for the Borough Council. The Town Clerk, Guildhall, Shrewsbury.

Southend-on-Sea, February 25.—Iron castings for 12 months from April 1, for the Corporation. Mr. R. G. Baxter, borough engineer, Municipal Buildings, Southend-on-Sea.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

493,935. SUTTON, H., LE BROCQ, L. F., and SAVAGE, E. G. Protection of magnesium-rich alloys against corrosion by electrolytic methods.

493,940. NAAMLOOZE VENNOOTSCHAP PHILIPS' GLOEILAMPENFABRIEKEN. Producing steel alloys for permanent magnets.

493,962. COMPAGNIE DES FORGES DE CHATILLON, COMMENTRY & NEUVES-MAISONS. Lengthwise casting of metallurgical products.

494,175. BAL, M. J. Heat-treatment of rail weldings.

494,306. AUSTIN MOTOR COMPANY, LIMITED, and SHEEHAN, J. J. Production of cast iron.

494,339-40. BIRMINGHAM ELECTRIC FURNACES, LIMITED, LOBLEY, A. G., and ROBIETTE, A. G. E. Annealing and other heat-treatment furnaces.

494,503. DAVIES, H. Surface treatment of iron and steel.

494,511. AUSTIN MOTOR COMPANY, LIMITED, and SHEEHAN, J. J. Cupola furnaces and the like.

494,656. MCDOWELL, C. H. Means for extracting dust or other suspended matter from furnace gases or the like.

494,661. TOOL METAL MANUFACTURING COMPANY, LIMITED. Hard metal alloys and tools and working parts made therefrom.

494,720. THOMAS & COMPANY, LIMITED, R., and DAVIES, D. H. Apparatus for the coating of steel sheets with tin or other metals.

494,862. REMY, VAN DER ZYPEN, & COMPANY. Process for the manufacture of strips or sheets of metal for tins for preserves, metal packings, and the like.

494,841. KOHLE- UND EISENFORSCHUNG GES. Articles requiring great resistance to creep and steel alloys therefor.

494,937. ACIERIES DU CENTRE, and MAGNEE, J. Method and device for the bottom-fed casting, through the feeding head, of all metals, and in particular of steel.

Forthcoming Events

FEBRUARY 20—MARCH 3.

British Industries Fair:—Engineering and Hardware Section at Castle Bromwich, Birmingham, 10 a.m.-6 p.m.

FEBRUARY 24.

Manchester Association of Engineers:—"Early Days of Mechanical Road Transport," Paper by H. Richardson (the Paper on "Modern Furnaces and Their Control" is postponed), at Engineers' Club, Manchester, at 7.15 p.m.

MARCH 1.

Manchester Metallurgical Society:—"Modern Methods of Melting Grey Iron in the Foundry," Paper by S. E. Dawson, at Blackfriars House, Blackfriars Street, Manchester, at 7.15 p.m.

Institute of British Foundrymen

FEBRUARY 27.

Falkirk Section:—"Cupola Control," Paper by H. P. Hughes, at Temperance Café, Lint Riggs, Falkirk, at 7.15 p.m.

MARCH 2.

Sheffield Branch:—"Foundry Drying and Coreshop Lay-out." Paper by W. H. Smith, at Royal Victoria Hotel, Sheffield, at 7.30 p.m.

MARCH 3.

Birmingham, Corentry and West Midlands Branch:—Joint meeting with Midland Section of Institute of Vitreous Enamellers. "Some Views on Cast Iron for Enamelling," Paper by S. Evans, at James Watt Memorial Institute, Birmingham, at 7.30 p.m.

MARCH 4.

Lancashire Branch:—"Rejects and Replaces in the Brass Foundry." Paper by W. Machin, at Engineers' Club, Manchester, at 4 p.m.

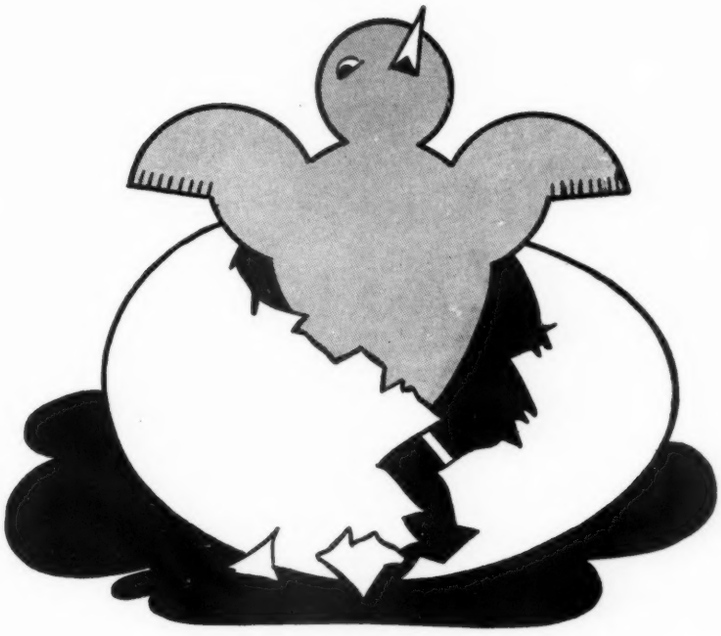
The Institute of Vitreous Enamellers

MARCH 2.

Northern Section:—Short Papers for discussion, at Queen's Hotel, Piccadilly, Manchester, at 7.30 p.m.

MARCH 3.

Midland Section:—Joint meeting with Birmingham Branch of Institute of British Foundrymen. (For details see above.)



EASTER REPAIRS

Winter is drawing to a close and with the awakening Spring come thoughts of the garden, the open road, holidays—time too, to think of Easter repairs.

Orders placed now for Firebricks, Silica Bricks, and Basic Bricks, etc., can be executed in time for your Easter repairs, enabling you to avoid the delay and disappointment which often accompany last-minute demands for supplies, so in your own interests order NOW.

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Raw Material Markets

The condition of the iron and steel trades does not improve very much from week to week, and were it not for the orders placed under the rearmament programme, the situation would indeed be very disturbing. There have recently been some indications that civil work is rather more plentiful than has been the case for a considerable time, but activity among shipbuilders and foundries is still very disappointing.

Pig-Iron

MIDDLESBROUGH. — The foundry pig-iron market in this area is still very quiet, and producers are receiving little new business. The position is not helped by the extensive use of scrap iron by the local foundries. Consequently, the output of Cleveland foundry iron continues to be very much curtailed. Prices have not been fixed up to any specific date, and many people hold the view that consumers are anticipating lower quotations later, and are therefore buying for immediate use only. This, of course, is possibly one of the reasons for the current slackness of trade, but it must be admitted that consumers in many cases are not well placed for work. No. 3 Cleveland G.M.B. foundry iron is quoted at 99s., with No. 1 foundry at 102s., and No. 4 foundry and No. 4 forge 98s., delivered in the Middlesbrough or Falkirk districts and less 5s. per ton rebate.

The outlook in the hematite section of the market is definitely improving, and, although orders are not at all heavy, the turnover in small tonnages for early deliveries is quite good. Local steelworks are now better employed, and are calling for hematite in larger tonnages under existing contracts. Producers are still in possession of substantial supplies, and it will inevitably be some time before the necessity for a higher output is forthcoming. Although quotations have been stabilised until the end of the first half of the year, there has been little inclination for buyers to cover their requirements so far ahead, and hand-to-mouth buying is the rule.

LANCASHIRE.—The foundry iron market in this area shows little improvement and, apart from the machine-tool and heavy electrical concerns, there has been no increase in trade among the consumers. The light-castings section remains particularly quiet. The widespread use of scrap is affecting to a large extent the consumption of foundry iron. Any new business that is placed is generally for small parcels to be delivered at a near date. Offers of Derbyshire and Staffordshire brands of No. 3 foundry iron for delivery to users in the Lancashire price zone are on the basis of 104s., with Northants No. 3 at 102s. 6d. and Derbyshire forge iron at from 101s. to 103s., according to the class of consumer. Contract deliveries of hematite are being taken up more freely, but there is little new inquiry about. West Coast brands are quoted at 128s. 6d. per ton and East Coast at 128s., both delivered in the Manchester district.

MIDLANDS.—The light-castings foundries in this area continue to be badly placed as far as new business is concerned, and consequently the demand for high-phosphorus pig-iron remains on the quiet side. It cannot be said that the outlook for this section of the trade is very promising, as the building industry, which is one of the largest consumers of castings, is still at a low ebb; the Ministry of Labour reports that the value of building plans approved in January was 15.2 per cent. below December and 29.4 per cent. under January, 1938. Producers of low-phosphorus iron are still doing a good trade and orders are coming to hand on quite a satisfactory scale. Prices of this iron are not controlled and this fact is no doubt partly responsible for the buying movement which has been noticeable for some time past. The consumption of hematite is better than it was during the closing months of last year, and, although new business is confined to small tonnages for early delivery, the outlook is satisfactory and it is expected that there will shortly be a resumption of heavy purchasing, as many contracts will shortly expire.

SCOTLAND.—Consumers continue to adhere to a policy of short-term buying and forward business is the exception rather than the rule. The production of eight blast furnaces is more than sufficient to meet the existing requirements of the trade. Present quotations of foundry iron are 108s. for No. 1 foundry and 105s. 6d. for No. 3, f.o.t. furnaces. The use of scrap at the foundries appears to be increasing. Local steelworks are working better time, but they are still remaining aloof from the iron market, existing commitments being adequate to satisfy their needs.

Coke

Business in foundry coke both on home and export accounts is good and makers are well booked. In the circumstances the coke-oven owners reaffirm their previous decision to maintain the minimum quotation for both best Durham and Welsh coke at 50s. 6d. per ton, delivered Birmingham and Black Country stations.

Steel

Business in the steel market has further improved and there is every likelihood of there being a good number of orders on hand at the steelworks for a long time to come. The improvement has largely been under the stimulus of the rearmament programme and civil work is still on the quiet side. The production of air-raid shelters is now well under way and orders for various products in connection with these shelters are substantial. The re-rollers have benefited from the heavier demand for small bars and strip, while boiler and tank makers are placing additional orders for plates. Full-time working is general among the sheet mills. Bright-drawn steel is in better demand and is likely to be taken up in heavier tonnages in the near future.

Scrap

During the past few weeks the tone of the iron and steel scrap market has changed for the better very considerably and merchants are disposing of their surplus stocks quite freely. Steelworks are calling for much heavier deliveries under contracts as a result of the enlarged production. In many cases it is not possible to comply with consumers' orders for prompt delivery, owing to the unexpectedness of the rush. Buyers are negotiating forward with greater confidence.

Metals

Non-ferrous metal markets have been quiet during the past week in the absence of any real support from consumers. There is little evidence that there will be any marked change in these conditions for some time to come.

Copper.—Producers continue to despatch deliveries under existing contracts quite freely, but there has not been much desire on the part of consumers to increase their commitments. The market has been further depressed by the January statistics, which showed that there was a further decline in ex-United States consumption during the month to 100,000 short tons, against 118,000 tons in December. Owing to this marked decline, the American Copper Institute's statistics reveal a further substantial rise in stocks, both in the United States and elsewhere. World refined stocks were 23,000 tons higher at 480,000 tons, the highest figure since last August. The increase was about evenly divided between U.S. stocks, which rose 11,000 tons, to 301,000 tons, and stocks in the rest of the world, which increased by 12,000 tons, to 179,000 tons. Although the United States refiners' quotation for copper continues to be 11.25 cents per lb., delivered Connecticut Valley, it is reported that there are ample supplies of metal available through second-hands at as low as 10⅜ cents. It is thought likely that this metal is refined scrap copper which has been bought cheaply by agents. It is further suggested that some producers are under-cutting quotations, although this is denied by the producers.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £41 8s. 9d. to £41 10s.; Friday, £42 to £42 2s. 6d.; Monday, £42 3s. 9d. to £42 5s.; Tuesday, £41 15s. to £41 17s. 6d.; Wednesday, £41 13s. 9d. to £41 15s.

Three Months.—Thursday, £41 16s. 3d. to £41 17s. 6d.; Friday, £42 6s. 3d. to £42 7s. 6d.; Monday, £42 10s. to £42 11s. 3d.; Tuesday, £42 2s. 6d. to £42 3s. 9d.; Wednesday, £42 to £42 1s. 3d.

Tin.—There has been little change in the position of this market. The weekly market report issued by Rudolf Wolff & Company states that "demand on the part of consumers in this country and on the Continent continues quiet. The London market has been subjected to moderate selling and liquidation by disappointed holders, while buyers at the same time adopted a reserved attitude, the general outlook providing little incentive to encourage operations on an important scale. It is certainly disappointing that consumers' demand should be so slow to recover, and this gives rise to rumours that the Committee may find it necessary to make some reduction in the existing quota. On the other hand, however, it seems more reasonable to anticipate that the already heavy reduction in output will prevent stocks unduly accumulating and that some recovery in consumptive demand, particularly in the United States, will eventuate. Confidence, however, is still the dominating influence, and this in turn is governed by the political outlook in Europe."

Official quotations were as follow :—

Cash.—Thursday, £211 15s. to £212; Friday, £213 5s. to £213 10s.; Monday, £213 15s. to £214; Tuesday, £213 7s. 6d. to £213 10s.; Wednesday, £212 10s. to £212 15s.

Three Months.—Thursday, £211 to £211 5s.; Friday, £212 10s. to £212 15s.; Monday, £213 to £213 5s.; Tuesday, £212 15s. to £213; Wednesday, £212 5s. to £212 10s.

Spelter.—A moderate demand for this metal has been received from the galvanisers during the past week, while the brass mills also have taken up quite good tonnages. The undertone of the market is firm, and the outlook is satisfactory. It is expected that there will be more orders in connection with the A.R.P. programme, and these will no doubt benefit the galvanisers.

Daily market prices :—

Ordinary.—Thursday, £13 5s.; Friday, £13 10s.; Monday, £13 11s. 3d.; Tuesday, £13 8s. 9d.; Wednesday, £13 8s. 9d.

Lead.—Although the demand for this metal is still disappointing, there has been a slight broadening of inquiry recently. On the whole, the outlook is not unsatisfactory, and several consuming industries should shortly be in a position to negotiate for further supplies.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £14 1s. 3d.; Friday, £14 6s. 3d.; Monday, £14 6s. 3d.; Tuesday, £14 5s.; Wednesday, £14 3s. 9d.

Scrap.—The home trade continues to be quiet and consumers have shown little disposition to place further orders. As yet permits for German imports are still small, but an increase may shortly be expected, although to what extent it is not known. Prices are unchanged on the week.

Approximate selling prices for old metal:—New aluminium cuttings, £70; rolled, £54 to £55; cast, £32; foil, £80. Copper, £38 to £42; braziery, £35. Brass (clean), £21 to £24. Zinc, £10. Lead, £13 5s. Gunmetal, £38.

Investigation of Some Relationships Between Variables of the Cupola

(*Continued from page* 172.)

the straight line $i_p = 0.7$, and curve "2" cuts it in a little explored region, that of very small blasts. A curve "3" can also be recognised.

It is easy to understand that runs situated on the left of curve "1" would be cold-iron runs, while those on the right of "2" would be runs with very good combustion, but with oxidation of the iron.

(*To be continued.*)

REFERENCES.

1 Aschenbach.—Die Giesserei, 1931.
2 Osann.—Eisen- und Stahlgiesserei.
3 Geiger.—Handbuch der Eisen- und Stahlgiesserei.
4 Le Chatelier.—Introduction à la métallurgie. Le chauffage industriel.
5 Schmidt.—Der Betrieb des Kupolofens.
6 J. J. Richards.—Metallurgische Berechnungen.

THE ANNUAL DINNER AND DANCE of the Manchester Association of Engineers will be held this year in the Jubilee Suite of the Grand Hotel, Manchester, on Friday, March 10, commencing at 7 p.m.